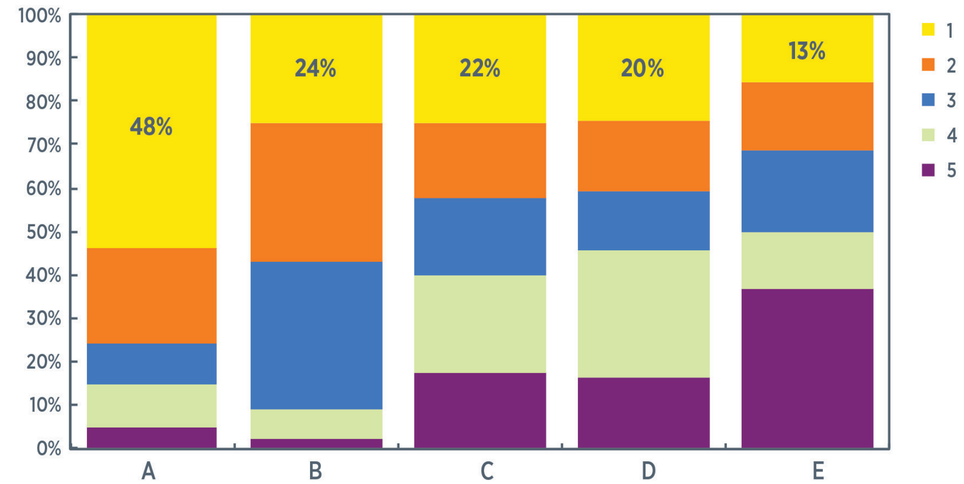
SSL DEMONSTRATION:

SSL Adoption by Museums: Survey Results, Analysis, and Recommendations

Since 2011, Jim Druzik and Stefan Michalski's "Guidelines for Assessing Solid-State Lighting for Museums" has been a pivotal resource for those seeking guidance in converting to SSL, which currently implies the use of light-emitting diodes (LEDs).

In June 2014, the Pacific Northwest National Laboratory (PNNL), on behalf of the U.S. Department of Energy (DOE), the Getty Conservation Institute (GCI), and the Canadian Conservation Institute (CCI), investigated the use of the Guidelines for the benefit of both the museum and SSL communities. A total of 979 questionnaires were successfully sent to members of the museum community who had requested a copy of the Guidelines, yielding 46 sets of responses (a 4.7% response rate). These responses provided real-world insight into how LEDs are being incorporated into museums, and what successes and hurdles have been encountered in the process.



Ranking	A	B	C	D	E
Mean	1.9	2.3	2.9	3	3.4
Mode	1	3	1	4	5
Min	1	1	1	1	1
Max	5	5	5	5	5
Mean rank	**1**	**2**	**3**	**4**	**5**

A Use a lighting source with equal if not lower damage potential
B Save energy and reduce cost/maintenance
C Improve color quality compared to standard
D Match color quality of standard museum lighting
E Inconspicuous transition from incandescent to LED lighting

Figure 1. Summary of the results for ranking lighting goals: The conservation benefits and energy savings from LEDs were prioritized more highly than improved color quality. A rating of one (yellow in the graph above) was the most favorable and a rating of five (purple) was the least favorable.

Museum Lighting Today

The GATEWAY report, SSL Adoption by Museums, includes museum requirements and goals, integrating sustainability and energy savings issues related to lighting; initial concerns and resolved misconceptions about LED technology; and the current lighting used in museums in consideration of how the Guidelines have been adopted to date. Of survey respondents, 68% placed a high priority on energy efficiency. However, despite the savings in energy and the reduced cost of operation gained by a source with high luminous efficacy, respondents indicated that their museums would not risk potential damage on their works of art nor sacrifice lighting quality in their galleries solely for the sake of energy efficiency (Figure 1).

Compared with over 55% of museum workplaces still using incandescent in 2009, 51% of respondents also identified incandescent as the principal lighting type, with LED at 40%, compact fluorescent (CFL) at 13%, linear fluorescent (FL) at 11%, and others (including metal halide, halogen, daylight) at 22%. The main difference between 2009 and 2014 lies in the higher percentage of LED adoption, now up to 40% compared to almost none. When asked whether they would consider and implement another LED installation, 71% indicated they would, only 6% would not, and 32% said they already had.

In the selection of lamps, color, spectral power distribution (SPD), and damage potential were the main considerations, with lamp efficacy, initial cost, and form factor (lamp size and shape) following. Some museums also prioritized the reliability of the manufacturer. Although 75% of respondents experienced early LED product failures, the maximum failure rate reported was only 2.5% of the installed lamps or fixtures. Noted sources of failure included electronic components such as drivers and power supplies, but not the LED source itself.

Barriers to Adoption

The report highlights the main perceived barriers to LED adoption, namely:

- Potential high cost, especially for dedicated LED fixtures;
- Difficult selection process, due to the confusing variety of products and difficulty keeping up with rapid advancements in technology;
- Resistance to change, especially from conservators and university administration; and
- Technology limitations, such as poor dimming performance and potentially problematic performance of LED replacement lamps in enclosed fixtures.

Respondents had no strong preference for replacement lamps versus dedicated LED fixtures. Instead, the decision was dependent on the application and the pressure exerted by existing luminaire stock. When evaluating color, almost all considered color rendering index (CRI), with target values greater than 85, two-thirds considered correlated color temperature (CCT), with 2700 and 3000 K listed as target values, and 60% evaluated the light source SPD. Only 26% required a color warranty. To resolve color inconsistencies, luminaires of similar color shift were grouped together or replaced by manufacturers. Two-thirds of respondents trialed expected illuminance levels and light sources in the actual gallery while less than half used a reserved space for mock-ups only.

When evaluating potential damage, the majority considered UV and IR content and about half considered short-wavelength emissions in the SPD. Other considerations included limiting the duration of exposure, CCT, heat output from LEDs, and the composition of displayed materials. Almost all respondents considered light exposure recommendations based on the sensitivity of the materials displayed, along with the annual hours of operation of the lighting system.

Dimming was generally deemed important to achieve required low light levels down to 5 fc (50 lux) incident on the object. Of respondents, 42% used DALI/DMX (Digital Multiplexing)/or 0-10V dimming protocol, 39% used dimmers designed for incandescent loads, and 33% had no dimming capabilities in galleries (12% used a combination of dimming methods). For dimmers not designed for incandescent loads, problems included flickering or failing to turn on.

The questionnaire responses and comments showed that there is still confusion about different LED products, what museum staff should be asking for, and concerns about maintenance. It was clear from the responses that education and experience are needed at multiple levels.

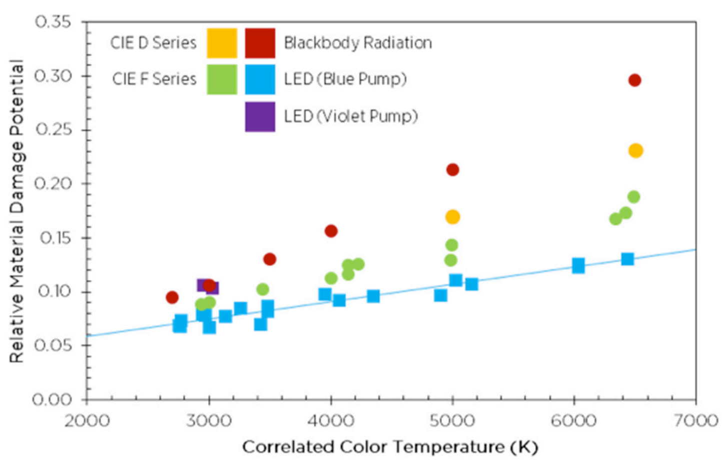


Figure 2. CIE spectral damage potential (S_{df}) versus CCT: The linear correlation between damage potential and CCT is high for all product types. The plot above is normalized for equal lumens from each light source.

Future Hope of LEDs

Although the energy savings from LED conversion are well known, lower damage potential and higher possibility for controls are other incentives for museum adoption. In general, white LEDs pose no special color issues (in rendering nor increased damage potential) for works of art, compared to an equivalent CCT halogen or fluorescent source. Regarding damage, at equal illuminance levels, the photochemical, thermal, and hygrometric stresses posed by LEDs are lower than halogen and (photochemically) much lower than daylight. Figure 2 shows the strong linear correlation between damage potential and CCT for all products. Lighting controls can eliminate 60% or more of wasted lighting energy in buildings and would enable the museum lighting designer to specify lighting exposure (illuminance, spectrum, time) to minimize damage while providing optimal viewing conditions. A growing and more sophisticated set of controllable LED light sources and complementary control technologies are becoming available.

Final reports on GATEWAY demonstration projects are available for download at http://energy.gov/eere/ssl/gateway-demonstrations.

GATEWAY Demonstrations

GATEWAY demonstrations showcase high-performance LED products for general illumination in commercial, municipal, and residential applications. Demonstrations yield real-world experience and data on the performance and cost effectiveness of lighting solutions. For more information, see http://energy.gov/eere/ssl/gateway-demonstrations.

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