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CC:	Jennifer Morris, Illinois Commerce Commission Randy Gunn, Jeff Erickson, and Carly Olig, Navigant
From:	Karen Maoz and Palak Thakur, Navigant
Date:	January 27, 2020
Re:	Effective Useful Life (EUL) Research for Commercial LED Fixtures

INTRODUCTION

This memo describes Navigant's research findings on estimating an LED fixture effective useful life (EUL) in non-residential facilities. The research goal was to identify the limiting factor that would define the EUL. Our research and data collection efforts sought to capture information related to the retention of LED fixtures and to determine the impact that these retention issues have on LED fixture installations and savings and targeted only measure persistence.

Ideally, to investigate the EUL of lighting installations, Navigant would visit facilities that had LED fixtures installed ten plus years ago; however, most of the LED fixture installations have occurred in the past three years. Therefore, the approach used for this research included a combination of literature review, customer surveys, and contractor interviews. None of the questions or responses could be related to the age of the removed LED fixtures since it is too early in the technology's lifecycle. Therefore, Navigant focused the research on unearthing how other factors relate to fixture life.

To complete this research, Navigant leveraged a combination of literature review, contractor interviews, and customer surveys. The key research questions were:

1. Determine fixture hours of use variation by facility type and if significantly different than the current Technical Reference Manual (TRM) hours of use assumptions
    a. Review LED manufacturer rated hours of installed fixtures
    b. Review hours of use assumptions
    c. Review literature for how switch rates impact measure lifetime
    d. Review studies on accuracy of rated hours
2. Understand if burnouts are a significant concern for lifetime savings and if they are addressed via ex post evaluation findings of early burnouts
    a. Are there instances of control compatibility issues affecting LED fixture life? How often does this occur?
    b. How often do LED lamp to fixture compatibility issues occur? How long after installation?
3. Capture data to understand how renovation cycles vary by facility type
    a. Determine tenant turnover rates and renovation cycles in commercial settings
    b. Survey, as part of existing participant survey frameworks, to determine average renovation cycle behavior.
    c. Do occupants replace all lighting when they move in? How often and to what level do they renovate?
    d. Is there enough differentiation to segment the population according to renovation propensity?

Based on Navigant's research, the EUL for LED lighting fixtures may be impacted by the following factors:

1. Variability in operating hours
2. Quality of the fixture and lamp installation
3. Timeline or frequency in which facilities conduct major renovations that result in the installation of new LED fixtures

The rest of this memo discusses the findings of the CY2019 research and Navigant's recommendations for next steps. Based on this research, Navigant recommends no change to the commercial LED fixture EUL.

LITERATURE REVIEW

Navigant looked at a comprehensive set of sources ranging from building factsheets, reports, case studies, online contractor articles, and blogs. The team researched all three influence factors (variability in operating hours, quality of installation, and timing of renovations) in the literature, prioritizing standard commercial building renovation cycles (for existing and new tenants) and whether lighting changes are included in the renovation. Navigant did not find any relevant statistics to provide data on commercial renovation or lighting retrofit rates. The literature review was mainly inconclusive for the three influence factors because the information available was too generic for the specific questions addressed by this research. Additionally, there are not many comprehensive studies available for LED fixtures for both lifetime and installation practices. Table 1 provides the highlights from the literature review but these findings on renovation cycles and early burnout are not sufficient to inform our research.

Table 1. Literature Review Key Findings

Source	Key Findings
Eurima* (2018)	In the European market, the typical renovation cycle is 30-50 years, but it is shorter for commercial buildings and reasons to renovate include financial, social, environmental.
University of New Haven** (2012)	Reported life span of office buildings is about 12-15 years to 20 years. Some studies assume a 50-year lifespan for office buildings. Department stores undergo big interior renovations for rebranding and marketing every 3-5 years.
Canadian Facility Management and Design† (2016)	"Many building owners and facilities managers are experiencing failure rates up to 20% or higher" for LED lamps. High failure rates are attributed mostly to poor quality materials and inadequate lamp testing. Data is inconclusive for current installations since it may not be applicable to LED fixtures and current generation technology.
Freedonia‡ (2018)	"In 2017, 70% of the general-purpose lighting fixture market was tied to either LED-integrated fixtures (often called luminaires) or LED-ready fixtures (used with separate LED bulbs or tubes). In that year, the latter made up most LED fixture sales, but LED-integrated fixtures will outpace LED-ready types and will be in the majority by 2022."

* "Deep Renovation," European Insulation Manufacturers Association, visited August 2019. https://www.eurima.org/energy-efficiency-in-buildings/deep-renovation.html.
** Aktas, Can B and M.M. Bilec, "Impact of Lifetime on U.S. Residential Building LCA Results," 2012. https://digitalcommons.newhaven.edu/cgi/viewcontent.cgi?referer=&httpsredir=1&article=1002&context=civilengineering-facpubs
† Cloud, Judy, "Four reasons LED lamps fail prematurely," for Canadian Facility Management Design, 2016. https://www.reminetwork.com/articles/14195/.
‡ Breuer, Matt, "The Pros & Cons of LED-Integrated Lighting Fixtures," for Freedonia Group, 2018. https://www.freedoniagroup.com/Content/Blog/2018/06/28/The-Pros--Cons-of-LED-Integrated-Lighting-Fixtures.
Source: Navigant

In addition to the above literature review, Navigant reviewed the "LED Lab Test Study" report prepared by Itron for the California Public Utilities Commission (CPUC).[1] This report contained the results of a large-scale performance test of LED lamps which were to be used to develop adjustments to the EUL assumptions for California. The bulbs in this report are subject to the Energy Independence Security Act (EISA) and are therefore not relevant to this study, which focuses on LED fixtures. The failure point from the Itron study was most relevant to those EISA lamps and not fixtures. Navigant searched for similar types of studies that address LED fixtures and did not find any.

ONLINE SURVEY RESULTS

Navigant analyzed ComEd's Small Business, Public Small Facility, and Standard Program participants' online survey results and the results are summarized in Table 2.[2,3] This dataset had 543 respondents across the three surveys (188 for Small Business, 41 for Public Small Facility, and 314 for Standard). Of these 543 respondents, 471 of them specifically completed a lighting project with ComEd. As a lesson learned from the Small Business and Public Small Facility Program surveys, Navigant added the last two questions in Table 2 to the Standard survey to understand the lifecycle of future renovations.

[1] Itron, *2013-2014 Work Order Ed_1_Ltg_1: LED Lab Test Study Final Report*, for the California Public Utility Commission, 2017. http://www.calmac.org/startDownload.asp?Name=LED%5FLab%5FTest%5FReport%5FFinal%2Epdf&Size=4865KB.
[2] Navigant leveraged existing survey plans to include questions related to EUL research. Navigant strategically designed the survey to meet the needs to limit survey time.
[3] Instant Discount program participants were not included in this survey as this program did not include the relevant LED fixtures for this study.

Table 2. Renovation Questions Survey Results

Survey Question	Small Business (n=188)	Public Small Facility (n=41)	Standard (n=314)
Lighting Project Count	187	41	243
How long has your business been at this location? (average)	23 years; 71/187 respondents have been at their location for 15 years or less (38%)	51 years, with 35% of sites between 26-50 years	32 years (223 lighting projects out of 314 respondents)
Did you renovate or update the facility when you moved to your present location?	101/187 said yes (54%);	0/1 said yes (0%)	-*
Did you update items or renovate lighting systems when you moved to your present location?	50/101 respondents said they updated lighting (50%) 51/71 respondents who have been at their location for 15 years or less said they updated lighting systems (72%)	-	-
Are you planning any future updates or renovations at your facility?	52/177 said yes (29%)	15/41 said yes (37%)	97/235 (41%) said yes
Will you update lighting at that time?	22/52 (42%)	5/23 (22%)	55/97 (57%) said yes
How often do you renovate or update your facility?	-	-	178 responses: average of 8 years with 38% every 2-4 years
When are you planning to make updates or renovations?	-	-	94 responses: 79% within 2 years

* A "-" denotes that these questions were not in the survey.
Source: Navigant

The results from the three programs show that most customers renovated the space and updated lighting after their move to the present location and that tenant turnover is not as common as expected. The average time a business was in the current space is over 20 years. Respondent customer segments were diverse including public buildings (e.g. libraries and schools), manufacturing, professional services, lodging, automotive repair and service, and others. There were not sufficient sample size data by segment to stratify results based on customer type.

The results for the Small Business Program survey show that almost half of the participants planning updates intend to include lighting in their future renovations. Additionally, for the Small Business Program, 54% said they renovated the space before moving in and 50% of those respondents did lighting retrofits.

The results from the Public Small Facility Program show that none of the customers renovated the space upon move-in or respondents did not answer since the average tenure at a site was greater than 26 years. Thirty-seven percent of respondents are planning to renovate in the future, with twenty-two percent planning to update lighting. A couple respondents provided insight into their reasoning behind renovating lighting when asked "when are you planning to update these systems and why":

- "Lighting will be this summer/early fall because it will save energy, lower cost. I don't think it will change the effectiveness of lighting itself."
- "The lighting will be part of a remodeling project that will start the second week of September, and that's the last remaining area that's not LED."

The results from the Standard survey provided more insight into the motivations behind renovation practices for customers. Most customers chose to renovate in order to replace old or outdated equipment. The Standard survey included additional questions after gathering lessons learned from the Small Business and Small Public Facility surveys. We added questions on when and how often the respondent is planning to renovate. In retrospect, the question "how often do you renovate or update your facility" could be ambiguous and could be interpreted as addressing non-energy systems, retrofitting the remaining lighting, or other activities. Almost 80% of customers planning to renovate said they would do so within two years.

CONTRACTOR INTERVIEW RESULTS

Navigant reached out to the top 15 contractors and 3 distributors with 8 contractor responses and 2 distributor responses. Navigant scheduled and conducted a total of 10 telephone interviews from the list of respondents from the ComEd contractor and distributor list for the Standard and Small Business Programs.[4] The distributor interviews did not provide relevant information and were excluded from the table below. Also, one contractor respondent was not included since they only work with one customer.

Table 3 provides a summary of key findings from the seven contractor interviews. The questions asked related to the influence factors (except for operating hours):

- Installation practices – any issues with tubular LED (TLED)[5] within existing fluorescent fixtures
- Installation practices – any issues with LED and control combability
- Fixture burnouts
- Renovations

[4] Navigant stopped recruitment at this time and no more contractors responded.
[5] TLED is a tubular LED specifically used to replace existing linear fluorescent lamps.

Table 3. Key Results from Contractor Interviews

Category		Key Points
Installation Practices	Compatibility	• Compatibility with controls often isn't an issue for contractors because most, if not all, of the LED fixtures have integrated controls.
	Age of removed equipment	• The approximate age of removed lighting, a combination of T-8s and T-12s, is 10 to 12 years old. • None of the contractors interviewed had replaced existing LEDs to date. • Contractors are not doing retrofits because the technology reached its end of life – they are doing retrofits because there is better technology and utilities are helping make these changes more cost effective.
Renovations	Percent of site renovated	• Contractors' responses varied depending on their customers. o During retrofits, most customers replaced entire portion of lighting onsite. o Most people are looking for ways to save money. • Multiple contractors mentioned that budget is the main constraint for whether the customer retrofits all lighting onsite vs. a portion of the fixtures.
	Customer behavior towards renovations	• Multiple contractors mentioned that the main factors for retrofits are cost of the project and return on investment. • Typically, tenants do not renovate because they do not own the space. The owner renovates for the tenants unless negotiated in the lease. • Regarding renovation cycles: o Economy drives tenant turnover. o A small percentage of the market, roughly 15-20% are doing renovations. o One contractor mentioned that lighting retrofits are rare for new tenant move-ins or tenants renovating (only one case recently).
Fixture Burnouts	Causes and how often	• Heat and corrosiveness are a huge factor in fixtures. These are affected by temperature of the ceiling, hours of operation, and environment. • One contractor has been installing LEDs for five years and has had no replacements of existing LEDs to date.

Source: Navigant

Navigant had a theory that there were probably premature fixture burnouts. The CPUC LED lamp study hinted that the general service lamps may have this issue. However, per the findings of the contractor interviews, it seems that LED fixtures do not have a similar problem. Additionally, at the onset of the emergence of TLEDs, there was broader industry concern that TLED replacements for T8 lamps were improperly installed resulting in compatibility issues. Another area of concern was related to the legacy controls being compatible with the new LED fixtures.

The contractors essentially said that they have had great success over the last three to four years of installations with minimal failure rates and call backs. If there is a product failure, this occurs in the first

couple of months. Two contractors have decided to only install one manufacturer that makes a high-quality product to reduce the failure rate. The expectation is that fixtures should last 10 or 15 years. One contractor stated that a higher probability of call backs occurs for TLED installations when the T8 ballast is kept as the driver. Of the contractors responding to the interviews, most focus on fixture retrofits versus TLEDs. Additionally, most contractors include fixture integrated controls and hence compatibility with legacy controls has not been an issue.

Due to the consistency in responses from the contractor interviews, Navigant chose to discontinue telephone interviews based on the eight completed. The following reasons support this decision:

1. Navigant learn that there is nearly zero rate of failure because contractors' LED fixtures are not failing and it may be too soon since most installations began about 3 years ago.

2. Contractors are doing retrofits by selling projects for energy savings rather than because there is a new tenant or as part of a larger renovation. Contractor understanding of renovation decision making and how often renovations may occur is most likely minimal.

3. Installation practices are not an issue affecting useful life unless there are TLED installations and original controls are maintained. The three contractors interviewed on this topic either have qualified installers or are using retrofit kits with integrated controls.

Conclusions and Next Steps

The literature review indicates that given the newness of the technology, there is little to be gained from existing documents to support changing the LED fixture EUL. The telephone interviews with contractors provided insight into their view of the market but also did not provide information that would support changing the EUL. The same is true with the online surveys.

Navigant considered other avenues of data collection, particularly for operating hours. Navigant considered reviewing the TRM EUL calculation based on the rated operating hours divided by TRM deemed annual operating hours. The rated operating hours is deemed in the TRM and tied to the minimum required in the Design Lights Consortium (DLC) standards (50,000 hours for most categories). However, the actual installed fixtures in the program may have a higher average. Navigant investigated and quickly abandoned the idea of reviewing make and model numbers from the rebated fixtures. The Small Business and Standard Programs do not collect this information in the tracking database and the Instant Discounts Program only had one fixture type.[6] Navigant did do a review of a subset of the DLC qualified product list. Of the indoor luminaires (which includes high bay, troffers, and 2x4 luminaires), 91% were rated at 50,000 hours. Therefore, actual fixtures installed ratings may typically be at the minimum rated hours.

The goal of the research was to identify the limiting factor in the EUL of commercial lighting. The top three areas identified were operating hours, installation practices (leading to early burnout), and renovation cycles. The research findings did not provide evidence that LED fixtures in commercial facilities may be replaced prior to the end of their technical life.

There are multiple barriers to gathering the appropriate data:

- Limited time on the market
- Technology innovation (better lighting and cost savings) triggers adoption
- Sample pool for understanding renovation practices

Some of the assumptions made about LED EULs were based on the initial entrants to market and minimal experience in the installation practices. Similarly, the contractors who do lighting retrofits have

[6] A review of invoices and any submitted spec sheets would need to occur to garner the necessary information.

gained insights and come up the learning curve on energy efficiency in the years of T8 and high bay T5 retrofits. Early in the emerging LED market, there were most likely poor judgements in installing controls, addressing compatibility, and choosing high quality products. Based on Navigant interviews, some of these issues have been addressed. However, there may be a bias since Navigant selected contractors with high market share to interview. Additionally, any self-installed projects were not captured by the contractor interviews.

Renovation Cycles

Ideally, any change to the EUL would be supported by ComEd-specific data by business type answering the following questions:

- How often do facilities renovate?
- How often do they replace the lighting fixtures when they do a renovation?
- How often does a tenant turn over – new lease or new owner?
- When a new tenant moves into a space, do they renovate (% who do) and do they replace the lighting fixtures?

In the customer surveys, Navigant collected some information to supply the responses to these questions, but the results were not strong enough to support a change in the EUL. The contractor surveys also provided insights on who contractors target and the decision-making of the customers. Contractors indicated that in most cases, a retrofit occurs because the contractor presented the customer with an incentive. Some contractors hinted that there is only an impetus to retrofit fixtures when a new technology (for example, LEDs) with better economics and lighting is introduced in the market. As a result, retrofits happen on different cycles than just on burnout. There was little to no information about renovations in the contractor interviews. Similarly, tenant turnover was not a topic the contractors were familiar with.

Connected lighting is increasingly positioned as a broader internet of things (IoT) play, and the contractor delivery model usually leverages the quick return on investment of lighting as a cornerstone of the more comprehensive retrofits especially for energy performance contracts. This may be the next trigger to result in retrofits.

Conclusions

For the future, Navigant recommends the following:

- Conduct more research surrounding operating hours of commercial buildings to see if hours are reduced as a result of more fixtures being controlled.
- Do retention studies once the LED fixtures (en masse) reach near the end of their useful life.

Navigant does not recommend making any EUL adjustments for LED fixtures in the TRM at this time.