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CC: Jennifer Morris, Illinois Commerce Commission
Randy Gunn, Jeff Erickson, Lucas Schroyer, and Carly Olig, Navigant
From: Karen Maoz and Palak Thakur, Navigant
Date: January 27, 2020
Re: Effective Useful Life (EUL) Research for Retrofit Add-on Measures

INTRODUCTION

This memo describes Navigant's research findings on non-residential sector retrofit add-on technologies' effective useful life (EUL) to date for HVAC controls and advanced lighting controls. In Navigant's previous value of information research, the interviewees indicated that the HVAC controls EUL is likely high and the advanced lighting control systems EUL is likely low; therefore, this research focused on just those two measure categories.¹

To conduct this research, Navigant used a combination of customer surveys and contractor phone interviews.² The surveys asked contractors when they replace the host equipment and under what conditions the existing controls (as a class and not differentiated by type) are replaced. This study only reviews the measure persistence, not savings persistence.

Retrofit add-on technologies refer to the measures that are applied to existing host equipment typically to control the host equipment operation. The host equipment can still operate without the add-on equipment. The Illinois Technical Reference Manual (IL TRM) currently defines the EUL based on the add-on equipment. Other states (for example, California) consider the control device persistence as it relates to the replacement of the host equipment, assumed as the remaining useful life. The theory from Navigant's previous value of information research is that the add-on technology is dependent on the host equipment. If the host equipment is replaced, the add-on equipment may not be compatible with the new host equipment or may be disposed of with the replaced host equipment.

This memo discusses the research findings and Navigant's recommendations for EUL changes and next steps. Navigant recommends an increase in the lighting controls EUL from 8 to 10 years and no change for the HVAC controls (including thermostats) EUL of 15 years.

ONLINE SURVEY RESULTS

Navigant analyzed online participant survey results from ComEd's CY2018 Standard Program evaluation. This dataset had 338 respondents across both free ridership and spillover surveys (167 respondents for spillover and 171 respondents for free ridership). However, only a smaller percentage of those participants responded to the EUL related questions. Table 1 provides a summary of the survey results relevant to the retrofit add-on EUL study.

¹ Since advanced lighting controls are not prevalent, Navigant opted on researching lighting controls as a proxy.

² Ideally, the implementer would have collected data surrounding the age of controls and equipment removed at inspection or other verification steps. However, the implementer procedures would be disrupted with this additional data collection step and hence no data was collected in this manner.

Table 1. Online Standard Survey Results

Survey Question	Total Respondents	HVAC Controls	Lighting Controls
Did the new controls replace previously existing controls?	72 [30 for HVAC Controls 42 for Lighting Controls]	70% said yes	64% said yes
Did you install the controller and update the controlled equipment at the same time?	72 [30 for HVAC Controls 42 for Lighting Controls]	90% said yes	86% said yes
How long had the controls been operating?	46 [21 for HVAC Controls 25 for Lighting Controls]	10% said less than 2 years 10% said 2-4 years 5% said 5-7 years 5% said 8-10 years 71% said 10 or more years	16% said less than 2 years 8% said 2-4 years 12% said 5-7 years 8% said 8-10 years 60% said 10 or more years
Why did you decide to replace the controls?	44 [20 for HVAC Controls 24 for Lighting Controls]	15% said "their contractor recommends it" 5% said "the incentive" 10% said "add new control of the system" 35% said "to replace failed equipment" 20% said "to control newly installed equipment" 15% said other with various other reasons such as better efficiency and newer technology	25% said "their contractor recommends it" 17% said "the incentive" 4% said "add new control of the system" 8% said "to replace failed equipment" 46% said "to control newly installed equipment" 8% said other with various other reasons such as better efficiency and newer technology
How old is the controlled equipment?	9 [3 for HVAC Controls 6 for Lighting Controls]	33% said less than 2 years 0% said 2-4 years 0% said 5-7 years 66% said 10 or more years	33% said less than 2 years 17% said 2-4 years 17% said 5-7 years 33% said 10 or more years

Source: Navigant

The respondent customer segments were diverse and included construction, professional services, manufacturing, computer equipment, public emergency services, lodging, and others. There were not sufficient data by segment to stratify results based on customer type.

The results from the Standard Program show that most customers had new controls replace old ones. Most respondents said the old controls were operating for more than 10 years and the main reason they decided to replace them was in order to control new host equipment. Other popular reasons included replacing controls because their contractor recommended it or because their equipment failed.

A majority of respondents, 88%, stated they installed the controls at the same time they updated their host equipment. This could indicate that the EUL of controls is very dependent on the condition of the host equipment as most customers tend to do these installations simultaneously. Navigant asked participants if they will need to replace the controls if they remove the host or controlled equipment. Only seven respondents answered this question, two for HVAC controls and five for lighting controls. Of these, only one respondent said yes for HVAC controls since the existing controller will not be compatible with newer equipment. Compatibility issues between older controls and new host equipment and vice versa could lead to early replacement of retrofit add-on measures. This concept is further explored with the contractor interviews.

TELEPHONE INTERVIEW RESULTS

Navigant reached out to the top 42 contractors between the Small Business and Standard Programs and conducted a total of 11 telephone interviews. Table 2 provides a summary of key findings from the 11 completed contractor interviews. Navigant focused the questions on the potential factors influencing installation or replacement practices including:

- Guidelines contractors follow when installing new controls onto existing host equipment
 - Age of host equipment
 - Condition of host equipment
 - Compatibility between host and control
- Age of existing or removed equipment
- Decision drivers surrounding when controls are replaced in relation to the host equipment

Table 2. Key Results from Contractor Interviews

Category	Key Points
Installation Guidelines for New Controls	<ul style="list-style-type: none"> • No specific age criteria for host equipment (often, contractors don't know or record age). Condition of the equipment is what matters. Contractors recommend replacing if customers have: <ul style="list-style-type: none"> ○ Older technology ○ Pneumatic or obsolete controls • Condition of host equipment plays a big role. If it is aged, not working, or not supported then contractors will try to replace the unit. <ul style="list-style-type: none"> ○ If the technology is in poor condition, the contractor wouldn't recommend adding controls but would instead replace with new fixtures integrated with controls. ○ For HVAC, in some cases the contractor will try to tune-up to see if they can extend the age of the equipment so it's functional immediately. If the unit is near the end of life, then it makes sense to replace the equipment in advance. • Compatibility drives the need for replacement. Contractors generally don't replace existing controls that are compatible with new fixtures. • Cost is a main factor when it comes to replacing controls. • Integrated controls have to be replaced upon failure of the host equipment. If not integrated, then contractors treat the controls and the host as separate entities. <ul style="list-style-type: none"> ○ Typically, controls remain in place if they are not integrated into the fixture.
Age of Existing or Removed Equipment	<ul style="list-style-type: none"> • Contractors had varying responses for age of lighting and HVAC controls: 10-15 years old, 20 years old, pneumatic from the 1980s • One contractor gave the following typical lifespans: <ul style="list-style-type: none"> ○ Lighting controls = roughly 10 years ○ Photocells = 2.5 to 4 years ○ Occupancy sensors = 40,000 to 70,000 hours ○ Timeclocks = they last forever • Age of removed equipment is around 20-years-old for lighting fixtures. • Mechanical equipment (host equipment) is typically a 30-year lifetime and what dictates replacement for host equipment is age, condition, misapplication, etc.
Decision Drivers for Replacing Controls when Replacing Host Equipment	<ul style="list-style-type: none"> • One contractor mentioned that controls are typically replaced at the same time as host equipment. • If controls are functioning properly, then the contractor needs to assess if there's more functionality or a need to upgrade for compatibility. • Only broken/faulty controls typically get replaced, independent of age. • Contractors will recommend controls if the host equipment does not have them. • Most contractors do not recommend new controls if the current controls function properly. • One contractor mentioned that if the customer has a timer, they do not recommend photocells because photocells are a clear failure point that will need maintenance in the future. • In order to achieve more savings and in some cases avoid compatibility issues, a few lighting contractors only install LED fixtures and controls at the same time.

Source: Navigant

Given the consistency in responses from the contractor interviews, Navigant suspended contractor interviews after the 11th complete. The rest of this memo focuses primarily on online survey results as the main source of information. The following reasons support this decision:

1. Navigant did not learn enough about the age of existing and removed equipment because contractors place emphasis on the condition of the host and the compatibility (up to date) of the control equipment instead of the age. Therefore, the age of existing or removed equipment is often not recorded.
2. Contractors who gave specific numbers for EUL estimates used their general knowledge of past projects instead of previous tracking data, therefore verification of the accuracy of these numbers is difficult.
3. Nature of lighting projects that were part of contractor population included cost effective solutions that include integrated controls. Therefore, there are other reasons for the replacement that are not indicative of future retrofits.
4. Existing controls are typically kept if compatible and functioning.

ANALYSIS

Navigant generated a best-fit probability distribution curve (Weibull distribution function)³ to the raw survey responses (across both lighting and HVAC controls) to the question “how long had the controls been operating.” There were 46 total responses with answer options of:

- Less than 2 years
- 2-4 years
- 5-7 years
- 8-10 years
- 10 or more years

In order to run a best-fit analysis to determine the survival curve, Navigant adjusted these bin ranges to generate the most likely static-point estimate per survey response. Before adjusting the EUL bin estimates, Navigant screened out “don’t know” survey responses as not applicable for the retrofit add-on EUL analysis. The first step in this analysis was to transform the EUL bin into an initial EUL estimate. To do this, the average of the bin range was calculated. For example, if a respondent indicated their controller had been operating between zero to two years the EUL for that response was calculated to be one year.

Seventy-one percent of survey responses to the aforementioned question were “10 years or more.” There is no upper limit for this EUL range and this option is the majority of responses. To address this issue, Navigant assessed two scenarios: one where the EUL is capped at 12 years to fit the two-year buckets defined in the other responses, and the other where the EUL is capped at 15 years, which is the current EUL for HVAC controls in the IL TRM.

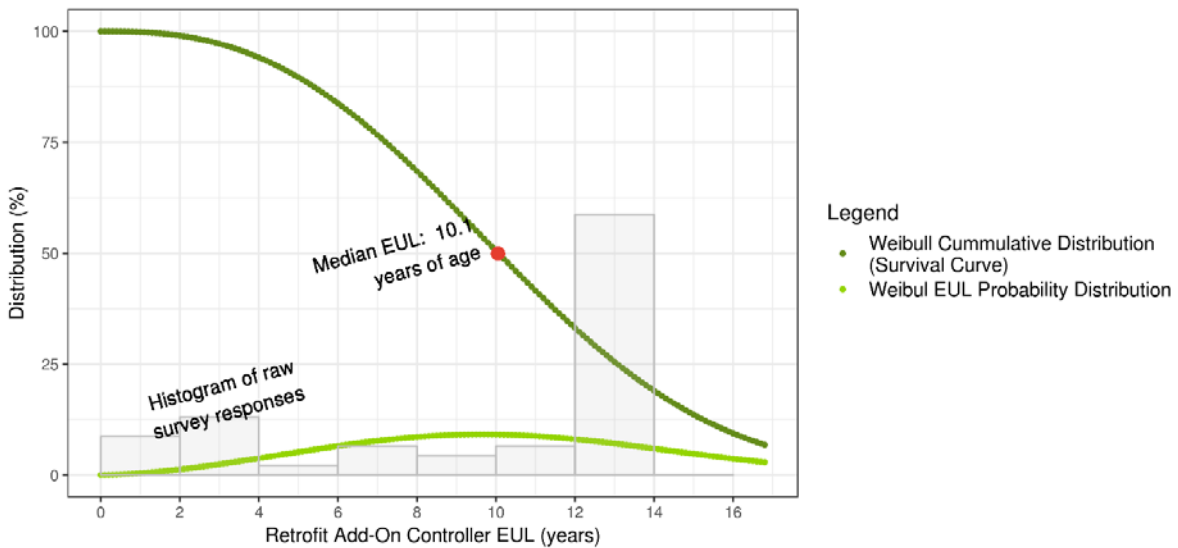
After transforming the EUL bin responses into point estimates, Navigant used numerical approximation optimization methods on the EUL point estimates to determine the best-fit Weibull distribution curve. The Weibull distribution function and cumulative distribution function, or the likelihood that a control is still operable and installed, are shown in Figure 1 and Figure 2.

When the EUL is capped at 15, as in Figure 1, the median EUL value for the fitted curve is 10.1 years. When the EUL is capped at 12 years, as in Figure 2, the median EUL is 9.3 years. Given most of the

³ The Weibull function is a type of probability distribution function that is widely used in product reliability assessments.

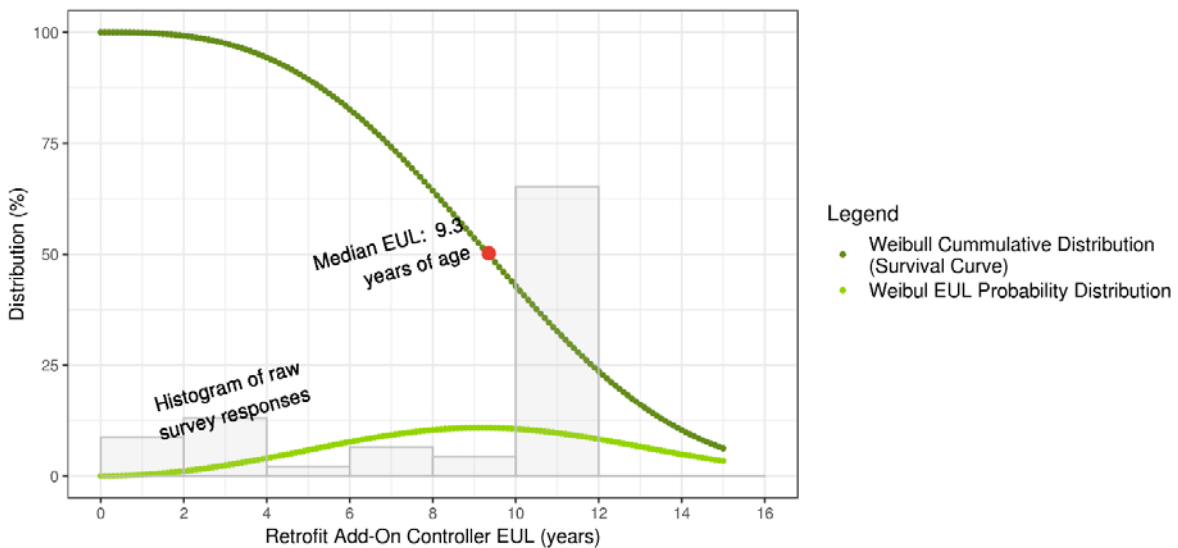
respondents chose “10 or more years”, whichever assumption is used to cap the EUL upper range (i.e. 12 years or 15 years) significantly impacts the survival curve median EUL. As a result, an EUL value of 10 years for retrofit add-on equipment for lighting controls is likely a more accurate value than the existing value in the TRM of 8 years, while the EUL for HVAC controls should remain at 15 years until future studies determine otherwise.

Figure 1. Retrofit Add-On Controller Survival Curve (responses capped at 15 years)



Source: Navigant

Figure 2. Retrofit Add-On Controller Survival Curve (responses capped at 12 years)



Source: Navigant

CONCLUSIONS AND NEXT STEPS

The online participant survey results provided us with helpful information to construct a survival curves that can support a new EUL recommendation. The telephone interviews provided useful qualitative

information but were inconclusive in providing verifiable data points. They were not informative enough to draw valid conclusions regarding the EUL of retrofit add-on measures.

Navigant considered other avenues of data collection, particularly for implementers to collect similar questions:

- Were there existing controls?
- Did the existing controls fail?
- Were the existing controls replaced to increase functionality and/or compatibility?
- What is the age of removed controls?
- What is the age of host equipment (existing or removed)?
- Are the new controls – integrated or not to host equipment?

Navigant recognizes that this data collection would be a burden on the implementer and participant and hence this approach was dropped from the scope of work. However, if there is an opportunity in the future to address these questions upon implementation, Navigant recommends pursuing this approach.

Per the findings of this current research, there is no indication that lighting controls should remain at an EUL of 8 years, and there is both qualitative and quantitative evidence to support our recommendation to increase it to 10 years. For the HVAC controls, there is no evidence to change the EUL and we recommend keeping it at 15 years.

The theory that the existing host equipment age or remaining useful life triggers an installation of new controls is not compatible with our research findings. Findings indicate that controls (if not integrated with the host equipment) may remain in place if they are still operational, compatible, and meeting functional needs.

Additionally, one of the concerns of the research questions was to consider the host equipment. The California Public Utilities Commission establishes that any add-on equipment EUL, such as controls, should be using the remaining useful life (defined as the one-third of the EUL) of the host equipment.⁴ However, most of the contractor interviews indicated that the host equipment is not the driver to replacing the controls since, in most cases, a new host and existing controls are typically compatible, especially with newer controls.

For the future, Navigant recommends the following:

- Implementers should collect data surrounding the age of controls and equipment removed at inspection.
- ComEd should conduct a savings persistence analysis for controls, since measure persistence seems to be of lesser concern. However, deemed savings measures (which are intended to represent average savings across a population of measures) may already account for savings persistence inherently. Consider, for example, a case where deemed unit energy savings are derived from the metered data from a sample of installed equipment that vary in age and operating patterns. The operational changes of this equipment over its lifetime may be captured by the average unit energy savings calculated from the sample of metered equipment.

⁴ Resolution E-4818 (<http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M179/K264/179264220.PDF>) reaffirmed the policy that EUL values for add-on equipment (AOE) measures are limited to the RUL values of the host equipment. The only exception to this is when the add-on measure is part of a new installation, in which case the EUL of the AOE is limited by the EUL of the host equipment.