# BUSINESS PARTNERS COMMERCIAL LIGHTING PROGRAM IMPACT EVALUATION

***Final***

Prepared For:

**New York State Energy Research and Development Authority (NYSERDA)**
Albany, NY

Tracey DeSimone

Assistant Project Manager, Evaluation

Jennifer Phelps

Project Manager, Evaluation

Prepared By:

**EMI Consulting**

83 Columbia St, Suite 400

Seattle, WA 98104

Ellen Steiner, Project Director

Jess Chandler, Project Manager

Consulting Team:

**EMI Consulting**

Industrial Economics, Incorporated (IEc)

September 2016

# Notice

# Table of Contents

# List of Figures



# List of Tables

# Acronyms and Abbreviations

| | |
|---|---|
| ASHRAE | American Society of Heating, Refrigerating and Air-Conditioning Engineers |
| CBES | Commercial Building Energy Standards |
| CLP | Commercial Lighting Program |
| HPT8 | High Performance T8 |
| IECC | International Energy Conservation Code |
| LED | Light Emitting Diode |
| LPD | Lighting Power Density |
| T5HO | T5 High Output |
| TRM | Technical Reference Manual |

# 1 Introduction

This evaluation includes a retrospective look at the Market Pathways Business Partners Commercial Lighting Program (Program) savings after program completion. The main objectives were to examine baseline assumptions used on a small sample of projects in order to make recommendations for baseline approach to be used in the planning and design of future, similar initiatives. This report is organized into four sections. Section One consists of an overview of the program; Section Two describes the evaluation objectives and approach; Section Three provides findings and recommendations; and Section Four details the references utilized in this study.

## 1.1 Program Overview

The Market Pathways Business Partners Commercial Lighting Program (CLP) provides training, assistance, and incentives to lighting practitioners (Business Partners), which include contractors, distributors, vendors and lighting designers. The program is both focused on energy savings and emphasizing appropriate lighting levels and fixture spacing during the design of retrofit and new construction lighting systems.

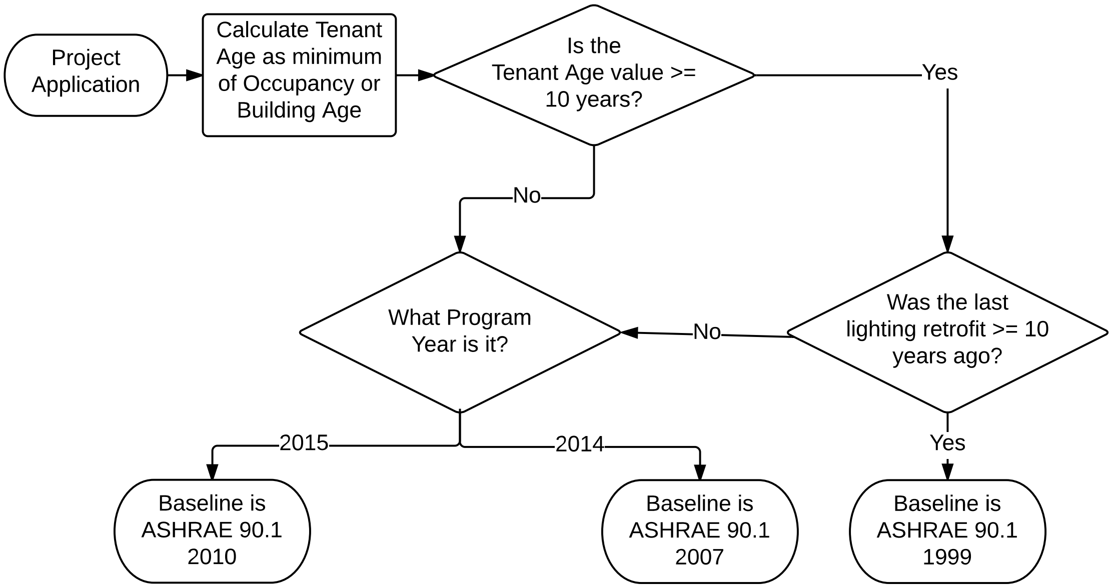
To meet program eligibility requirements, the retrofit or new lighting systems must result in a lighting power density (LPD) 10% lower than code allowance. Project savings and nominal design incentives for Business Partners are based upon the difference in the total estimated annual consumption of the project LPD compared to the baseline standard LPD, given the size of the facility, the presence of occupancy controls, and the facility's annual hours-of-use. The comparison of LPD is on a space-by-space basis, utilizing the baseline standard for each type of space (e.g., e restroom, open office, classroom). Similarly, occupancy controls increase the savings for the controlled portion of the facility by an estimated 30%.

The baseline standard LPD is based on the New York State code. The New York State Energy Conservation Codes (ECCCNYS) are as follows:

- ECCCNYS2014 – ASHRAE 90.1-2010 – Effective January 1, 2015
- ECCCNYS2010 – ASHRAE 90.1-2007 – Effective December 28, 2010
- ECCCNYS2007 – ASHRAE 90.1-2004 – Effective January 1, 2008
- ECCCNYS2002 – ASHRAE 90.1-1999 – Effective July 1, 2002

The decision structure for determining the baseline standard LPD is illustrated in **Figure 1-1**. First, the tenant age is calculated as the building age or tenant occupancy of the building, whichever is less. If the building is 10 years or older, and the last lighting retrofit was more than 10 years prior, the Baseline is ASHRAE 90.1 version 1999. However, if either the occupancy or the last lighting retrofit was more recent, the program baseline is based on the program year. If 2014, the baseline is version 2007. If 2015, the baseline is version 2010. Note that the decision structure excludes ASHRAE 90.1 2004; these facilities are directed to the 2007 version.

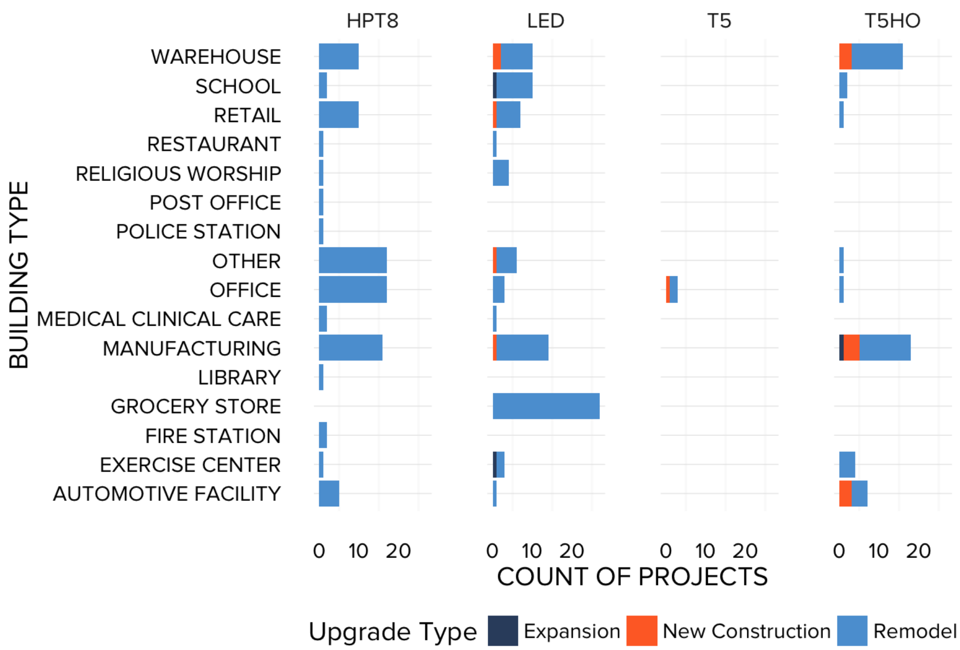
**Figure 1-1. Decision Structure for Determining Baseline Standard**




For reference, the project database includes 231 projects with applications received between September 26, 2012 and December, 6, 2015; an additional four projects were missing data points and therefore were dropped from the analysis. The project data includes the characteristics of upgrade type, building type, and installed lighting technology type.

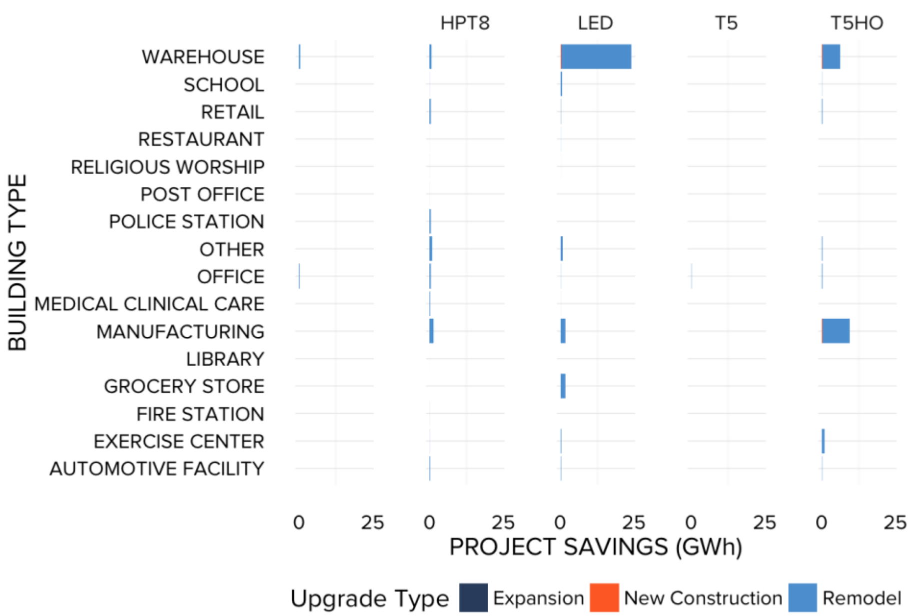
The most common upgrade type is a remodel, as opposed to new construction and expansion. Many building types were represented in the database. These projects included four primary technology types: HPT8, LED, T5, and T5HO. The most common technology/building combinations by count are LED lighting within grocery facilities and T5HO lighting in manufacturing facilities, as shown in Figure 1-2.

**Figure 1-2. Project Count Distribution by Building Type, Upgrade Type, and Primary Technology**




The most savings are from LEDs in warehouse facilities, as shown in Figure 1-3.

**Figure 1-3. Project Savings Distribution by Building Type, Upgrade Type, and Primary Technology**



# 2 Evaluation Approach

This section lists the evaluation objectives and describes the steps taken in the evaluation to answer the objectives.

## 2.1 Evaluation Objectives

The impact evaluation had three objectives:

1. Compare baseline assumptions used in Program projects with Technical Reference Manuals (TRMs).
2. Evaluate the energy savings from 20 sample projects completed in 2014-2015.
3. Make recommendations for baseline approach to be used in the planning and design of future, similar initiatives.

To meet these objectives, the evaluation team completed three overarching tasks: a desk review to verify that the correct Program baseline methodology was applied correctly, a review of secondary sources to compare the Program baseline methods to prevalent methods used in other jurisdictions, and a calculation of savings under alternative baseline methods. Although this evaluation was not designed or intended to calculate a program-level realization rate, the authors provide a realization rate to show the savings for the program with the accepted baseline assumptions. It should be noted that the realization rate shown for illustration and summary purposes in this report does not meet a 90/10 sampling precision level. Each of these tasks is described in more detail in the following sub-sections.

## 2.2 Desk Review

The evaluation team conducted a desk review of a sample of 20 projects completed between 2014 and 2015. The documentation included inspection reports from on-site verifications conducted by the implementer at the end of 2015, a data export from the program tracking database, and project applications. One project was excluded due to incomplete data, thus a total of 19 projects were evaluated. These 19 projects were selected because they had recent on-site verification visits. They include projects across several facility and technology types, including the most common and the ones with the highest savings.

The evaluation team entered key information from each project into a Savings Analysis Tool developed by the evaluator, including fixture types and quantities, lamp or fixture watts, facility operating hours, and occupancy sensors. The tool re-calculated project-level savings using the Program defined space-by-space LPD approach, identifying the appropriate baseline LPD by space to compare with the project LPD. The tool also re-calculated project-level savings using the alternative baseline assumptions determined through the review of secondary sources, detailed below.

## 2.3 Review of Secondary Sources

The evaluation team conducted a review of secondary sources for the most prevalent baseline methods used across a sample of other jurisdictions. The secondary sources reviewed are listed here:

- New York Standard Approach for Estimating Energy Savings from Energy Efficiency Measures
- Vermont TRM
- Massachusetts TRM
- Rhode Island TRM
- Mid-Atlantic TRM (which includes separate LPD for Delaware, Maryland, and the District of Columbia)
- Connecticut Program Savings Document
- New Jersey Clean Energy Program Protocols to Measure Resource Savings
- The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures, specifically Chapter 2: Commercial and Industrial Lighting Evaluation Protocol, and Chapter 3: Commercial and Industrial Lighting Controls Evaluation Protocol

The evaluation team found that the prevalent baseline methods in these secondary sources fell into one of three categories:

1. Prescriptive baseline wattages (an assumed baseline condition lamp): This method makes an assumption about the fixtures that would have been replaced. Both the Mid-Atlantic and the Vermont TRMs include a prescriptive wattage option.
2. Baseline LPD (an assumed level of LPD): This method makes an assumption about the LPD in the pre-installation case based on an expected standard by space or by facility. The program uses this method on a space-by-space basis, along with Connecticut, Massachusetts, Maryland, New York, New Jersey, and Vermont.[1] While the District of Columbia and Delaware technically use a facility method by referencing IECC 2006/2009, but the Mid-Atlantic TRM distributes them across spaces.[2]
3. Actual baseline: This method uses the actual pre-installation LPD or fixture wattages. There is no data in the database on the actual pre-installation condition (the counterfactual), so this method is not a viable alternative to consider for comparison here.

## 2.4 Alternative Savings Calculations

The evaluation team re-calculated the savings for each sample project with the assumptions given in the secondary sources. In total, each sample project ended up with a total of seven savings estimates, six of them calculated by the evaluation team:

1. Database: The savings value in the program database
2. Verified: The savings calculated using the Program methodology based on the on-site verification data.

---

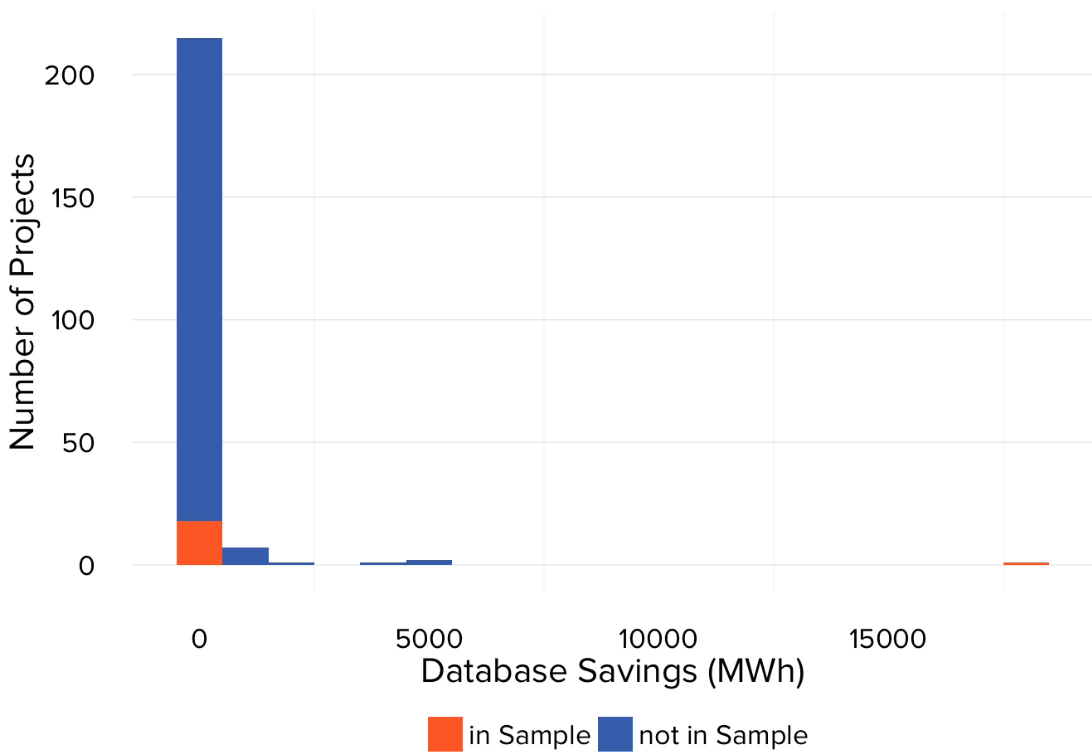
[1] For CT, MA, NY, and NJ, space-by-space LPDs are directly referenced from ASHRAE 90.1 2007. The TRM in MD uses the IECC 2012. The TRM in VT refers directly to the 2005 CBES, which uses LPD from ASHRAE 90.1 2007 by reference, and the 2011 CBES, which uses LPD from the IECC 2012 by reference.

[2] Section 505.5 of the 2009 IECC maintains the same interior lighting power allowances as the 2006 IECC but adds more exceptions in Section 505.5.1. For this reason, the interior lighting power allowances for the 2006 and 2009 IECC are generally considered equivalent.

3. ASHRAE 90.1 2007: The savings calculated assuming the baseline LPD was equivalent with the standard in ASHRAE 90.1 2007 for the space.
4. IECC 2006/2009: The savings calculated assuming the baseline LPD was equivalent with the standard in the Mid-Atlantic TRM for the District of Columbia and Delaware, referencing IECC 2006/2009 for the space.
5. IECC 2012: The savings calculated assuming the baseline LPD was equivalent with the standard in IECC 2012 for the space.
6. Mid-Atlantic Prescriptive Wattage: The savings calculated assuming the baseline fixture was as identified in the Mid-Atlantic fixture lookup tables.
7. Vermont Prescriptive Wattage: The savings calculated assuming the baseline fixture was as identified in the Vermont fixture lookup tables.

We conducted post-stratification for the verified savings to establish a program realization rate. We split the projects into two strata based on database savings.[3] This is due to one project that was significantly larger than all of the others, and this project was included our sample (see Figure 2-1).

**Figure 2-1. Project Distribution by Project Database Savings**




[3] We also considered building type and primary technology as stratification variables.

Summary statistics for the strata are shown in Table 2-1. Case weights reflect the number of projects in the population that are represented by each project in the sample.

**Table 2-1. Summary of Strata**

| Strata | Min (kWh) | Max (kWh) | Mean (kWh) | Sum (kWh) | Population Count | Sample Count | Case Weight |
|---|---|---|---|---|---|---|---|
| All Other | 340 | 4,782,700 | 149,139 | 33,705,450 | 226 | 18 | 12.56 |
| High | 18,144,159 | 18,144,159 | 18,144,159 | 18,144,159 | 1 | 1 | 1.00 |

# 3 Findings and Recommendations

This section includes our alternative savings calculation summaries (findings) and recommendations for baseline calculations in future initiatives throughout the State.

## 3.1 Findings

For the findings, we first address the verified savings from the desk reviews and then the alternate calculations.

### 3.1.1 Verified Savings

Based on post-stratification, the total verified savings are 45,119,575 kWh with a margin of error of +/- 8,843,437 kWh as shown below in Table 3-1.[4]

**Table 3-1. Verified Savings**

| Strata | Database kWh | Verified kWh | Margin of Error |
|---|---|---|---|
| All Other | 33,705,450 | 27,638,165 | 15,504,507 |
| High | 18,144,159 | 17,481,411 | -- |
| Total | 51,849,609 | 45,119,575 | 8,843,437 |

The savings are based on the calculated realization rate. The total verified realization rate is 87% with a margin of error of +/-19.6% at 90% confidence. As shown below in Table 3-2, the realization rate for the single project in the "High" strata is 96%; the realization rate for "All Other" projects is 82% with a margin of error of +/-46% at 90% confidence.

**Table 3-2. Realization Rates for Database Stratified by Savings**

| Strata | Coefficient of Variation | Standard Error | Mean Realization Rate | Error Ratio | Margin of Error (90% Confidence) |
|---|---|---|---|---|---|
| All Other | 0.32 | 0.28 | 0.82 | 1.05 | 0.46 |
| High | | 0.00 | 0.96 | 1.00 | 0.00 |

The margin of error is high because there is a great deal of variation in the verified realization rates for each underlying projects, ranging from 27% to 136%. Table 3-3 shows the database savings and verified realization rates for each sample project.

[4] If we do not stratify, the resulting total verified savings are 49,288,683 kWh, reflecting a verified realization rate of 95.1% with a margin of error of +/− 138.2% at 90% confidence.

**Table 3-3. Sample Project Level Database Savings and Verified Realization Rates**

| Project | Database Savings (kWh) | Verified | Reason for Difference between Database and Verified Savings |
|---|---|---|---|
| J3019 | 33,228 | 27% | Baseline LPD should be 1.1 (exercise area); 2.1 was used. Also, lower fixture wattage on inspection than application. These adjustments are in opposite directions. |
| J3046 | 48,631 | 101% | -- |
| J3052 | 4,680 | 59% | Application fixtures (24) do not match inspection fixtures (27). This results in higher wattage in the verified case. |
| J3068 | 18,144,159 | 96% | Baseline LPD should be 3.0 (Warehouse High Bay); 3.1 was used. |
| J3116 | 30,978 | 110% | Baseline LPD should be 0.2 (parking garage); 0.178 was used. |
| J3125 | 96,185 | 54% | Baseline standard 2010; Database had 1999. Also, lower fixture wattage on inspection than application. These adjustments are in |
| J3129 | 19,718 | 92% | After the project was completed, there was a change in space and number of fixtures. |
| J3136 | 55,900 | 104% | Lower fixture wattage on inspection than application |
| J3137 | 35,006 | 101% | -- |
| J3143 | 436,738 | 46% | Database uses baseline LPD of 3.0 instead of 1.7. Also, total watts 21,384 in database and 21,060 in inspection. These adjustments are in opposite directions. |
| J3144 | 106,560 | 112% | Baseline LPD 2.9, not 3.0; PAR 38 LED 19W, not 150W. |
| J3145 | 42,576 | 136% | PAR 38 LED 19W, not 150W; Quantity differs - 30 not 31 |
| J3148 | 8,407 | 117% | Total watts 6,540 in database and 5,995 in inspection. |
| J3153 | 81,114 | 100% | -- |
| J3155 | 118,762 | 100% | -- |
| J3165 | 394,243 | 99% | -- |
| J3168 | 167,432 | 99% | -- |
| J3193 | 18,431 | 100% | -- |
| J3201 | 88,446 | 54% | Inspection report wattages differ from application wattages |

Of the 19 projects, seven had no major differences between the database savings and verified project savings; these are indicated with a -- in the table above. The other 12 projects had four underlying causes (some more than one) of differences or adjustments in the verified calculations:

- Inspection Watts/Fixture differs from Application: 7 projects
- Baseline LPD error: 5 projects
- Inspection fixture count differs from Application: 3 projects
- Baseline year error: 1 project

For verified savings, the dominant cause of negative adjustments was errors in the Baseline LPD. The dominant cause of positive adjustments was lower watts in the inspection compared to the application.

### 3.1.2 Alternate Savings

Alternative calculations had variable realization rates from the database savings, with the general direction of adjustments being negative, as shown in Table 3-4. Using the same method described above for verified savings, program level realization rates for each approach (and the associated margins of error) are included in the last two rows. However, these realization rates are for information purposes only, as they reflect a method of calculating the baseline that is different from the program design.

**Table 3-4. Sample Project Level Database Savings and Alternative Realization Rates**

| Project | Database Savings (kWh) | IECC 2006/ 2009 | IECC 2012 | ASHRAE 2007 | Mid-Atlantic prescriptive | VT prescriptive |
|---|---|---|---|---|---|---|
| J3019 | 33,228 | 12% | 12% | 12% | 13% | 0% |
| J3046 | 48,631 | 102% | 101 | 101% | 36% | 31% |
| J3052 | 4,680 | 59% | 59% | 59% | 0% | 0% |
| J3068 | 18,144,15 | 22% | 11% | 22% | 2% | 11% |
| J3116 | 30,978 | 110% | 110 | 110% | 644% | 691% |
| J3125 | 96,185 | 58% | 46% | 45% | 11% | 0% |
| J3129 | 19,718 | 39% | 39% | 39% | 0% | 11% |
| J3136 | 55,900 | 41% | 41% | 41% | 9% | 0% |
| J3137 | 35,006 | 103% | 103 | 103% | 0% | 0% |
| J3143 | 436,738 | 33% | 33% | 33% | 0% | 7% |
| J3144 | 106,560 | 102% | 97% | 102% | 8% | 31% |
| J3145 | 42,576 | 122% | 116 | 122% | 19% | 52% |
| J3148 | 8,407 | 70% | 47% | 70% | 91% | 13% |
| J3153 | 81,114 | 66% | 66% | 66% | 7% | 33% |
| J3155 | 118,762 | 43% | 43% | 43% | 2% | 25% |
| J3165 | 394,243 | 188% | 104 | 188% | 16% | 25% |
| J3168 | 167,432 | 139% | 139 | 139% | 16% | 55% |
| J3193 | 18,431 | 35% | 35% | 35% | 104% | 100% |
| J3201 | 88,446 | 129% | 127 | 128% | 11% | 54% |
| Stratified Realization Rate | -- | 70.1% | 53.6 % | 69.7% | 14.9% | 13.3% |
| Margin of Error (+/-) | -- | 24.5% | 19.8 | 24.5% | 12.5% | 16.1% |

Discussion of these alternatives focuses on two groups: the LPD methods and the prescriptive methods. For the LPD methods (columns: IECC 2006/2009, IECC 2012, and ASHRAE 2007), the differences are due to changing LPD standards for the spaces. In general, the trend is to lower allowed LPD in later years (with bathrooms as an exception). For many sample projects, applying the more recent standards is not in line with the Program theory because the tenant age may lead to an expectation of a different baseline.

The differences for prescriptive wattages are almost entirely due to missing or higher wattage baseline fixtures in the prescriptive lookup table than the project wattage. This method does not align with the structure of the energy efficiency code in the State and may result in savings attributable to fixtures that are not reasonable for the space.

## 3.2 Recommendations

This section summarizes two key recommendations that NYSERDA and other entities may want to consider in developing baseline calculations for future lighting initiatives.

1. Consider using project specific (custom) calculations instead of deemed savings values. This is consistent with the previous Program theory, which focuses on encouraging designers to achieve the best lighting in a space.
    a. Continue to use space-by-space LPD rather than prescriptive fixture savings to be consistent with the State energy codes. This is the appropriate frame of reference for designers.
    b. The reference baseline code decision structure should ensure that the current code is the baseline when more than the trigger level of lighting is adjusted for retrofit and expansions. For the last two versions of the State code, this has been 10% of connected lighting load. Previously, it was 50% of the connected lighting load.
    c. We recommend customizing the calculations of occupancy controls. Occupancy sensors should be treated on a space-by-space basis. The Program practice of an additional 30% savings attributable to occupancy controls is common practice, but it likely overstates savings. When controls are present in the baseline or controls are required as part of the code, additional savings for including controls are not appropriate. Changing the kind of controls, from space to fixture level occupancy or to include daylighting will also require custom calculations.
2. Improve project quality assurance protocols. The majority of adjustments between database and verified savings were due to errors in documentation – either LPD or wattage.
    a. Continue to conduct verification visits to confirm actual wattages installed and space dimensions for a sample or where merited based on a risk analysis findings. This can be performed by the program implementer or a third party and act as a check on the installer.
    b. Conduct review of assumed baseline LPD values as a separate line item from document review. This could include a checklist that the correct baseline year was identified (based on tenant age, portion of connected load remodeled, and code in place) and that the correct LPD was used for the space.
    c. Enable the program administrator to quickly flag projects with extreme values. Substantially low values of installed LPD or high values of baseline LPD may indicate an error in calculation of space dimensions or entry of fixture wattage or count.

# 4 References

Connecticut Department of Public Utility Control. 2014. *Connecticut Program Savings Document, 10th Edition for 2015 Program Year*. http://www.dpuc.state.ct.us/DEEPEnergy.nsf/c6c6d525f7cdd1168525797d0047c5bf/8525797c00471adb85257db600666127/$FILE/2015%20Program%20Savings%20Documentation%20.pdf

Efficiency Vermont. 2015. *Technical Reference User Manual (TRM) Measure Savings Algorithms and Cost Assumptions*, TRM User Manual No. 2014-87. http://psb.vermont.gov/sites/psb/files/docketsandprojects/electric/majorpendingproceedings/TRM%20User%20Manual%20No.%202015-87C.pdf

Massachusetts Electricity and Gas Energy Efficiency Program Administrators (Mass Saves). 2012. *Massachusetts Technical Reference Manual for Estimating Savings from Energy Efficiency Measures*. http://ma-eeac.org/wordpress/wp-content/uploads/TRM_PLAN_2013-15.pdf

National Grid. 2015. *Rhode Island Technical Reference Manual For Estimating Savings from Energy Efficiency Measures*. https://www9.nationalgridus.com/non_html/eer/ri/PY2016%20RI%20TRM.pdf

New Jersey Board of Public Utilities. 2012. *New Jersey Clean Energy Program Protocols to Measure Resource Savings*. http://www.njcleanenergy.com/files/file/NJ%20Protocols%20Revisions%208-14-12_Clean(1).pdf

New York State Department of Public Service. 2014. *New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs – Residential, Multi-Family, and Commercial/Industrial Measures,* Version 2. http://www3.dps.ny.gov/W/PSCWeb.nsf/ca7cd46b41e6d01f0525685800545955/06f2fee55575bd8a852576e4006f9af7/$FILE/TRM%20Version%202%20December%2010,%202014.pdf

Northeast Energy Efficiency Partnership (NEEP). 2015. *Mid-Atlantic Technical Reference Manual*, Version 5.0. http://www.neep.org/sites/default/files/resources/Mid-Atlantic_TRM_V5_FINAL_5-26-2015.pdf

U.S. Department of Energy. 2013-2015. *Uniform Methods Project*. http://energy.gov/eere/about-us/ump-protocols