REPORT

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Business Incentive Program Impact Evaluation

Submitted to Efficiency Maine Trust

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1 Executive Summary

The Efficiency Maine Trust (Efficiency Maine or EMT) retained Nexant to evaluate the commercial, demand-side management (DSM) programs available through its Fiscal Year 2014 and 2015 Business Incentive Programs (BIP) umbrella. This report summarizes the impact findings of the 2014 and 2015 program cycle activities. Process evaluation results were presented in the previously submitted report titled “EMT Business Incentive Program Process Evaluation Report_Final_103116”.

For this evaluation, Nexant combined thirteen evaluated programs into four discrete strata (Table 1-1), grouped by similar program characteristics and end-uses when possible. Impact evaluation results are presented throughout this report for each discrete stratum.

Table 1-1: Included BIP Program Strata Assignment within 2014-2015 Evaluation

Nexant Stratum	Business Incentive Program
Custom Rebates	Custom compressed air Custom heating, ventilation, and air conditioning (HVAC) Custom lighting Custom miscellaneous
Ductless heat pumps	Prescriptive ductless heat pump (DHP)
Prescriptive lighting	Prescriptive lighting new construction Prescriptive lighting Retrofit
Prescriptive non-lighting	Prescriptive agriculture Prescriptive compressed air Prescriptive HVAC Prescriptive refrigeration Prescriptive VFD

BIP program umbrella also included custom natural gas and prescriptive natural gas programs, which are not included in this evaluation.

1.1 The Business Incentive Program

Efficiency Maine’s BIP provided education, technical assistance, quality control, and financial incentives to encourage a wide range of energy-efficiency projects in commercial and industrial buildings throughout Maine. Projects that qualified for more than $5,000 of incentives required pre-approval. The program offered both prescriptive incentives and custom incentives.

Prescriptive incentives were available for projects that save electricity through lighting, DHPs, HVAC, VFDs, refrigeration, compressed air, and agricultural equipment upgrades. Approximately 95% of program-sponsored projects were prescriptive.

Custom incentives were available for projects expected to result in energy savings, but were not eligible for prescriptive incentives because the project was too large or too complex. Costs and savings associated with custom projects vary by application and are generally large; to be eligible for non-prescriptive incentives, the project must have resulted in annual energy savings of 35,000 kWh or more. Custom incentives for retrofit projects were capped at 50% of the total cost of the efficiency project including labor, and at $0.28 per first year of kWh saved.

A network of Qualified Partner (QP) trade allies supported the program, identifying and installing eligible measures and supporting participating customers. Efficiency Maine had focused on expanding and improving the QP network by providing easier access to information and program tools through a dedicated website and through outreach efforts conducted largely through the program's implementation contractor, GDS Associates (GDS). The program provided periodic training for QP firms to increase their understanding of the benefits of energy efficiency, how to use and maintain emerging high-efficiency technology, best practices in energy efficient design, and resources available from Efficiency Maine. GDS supported the QP network by providing program support, managing the application and incentive payment process, and ensuring that QPs had the tools they needed to successfully promote the program.

1.2 Evaluation Goals and Activities

The primary goals and objectives of the impact evaluation of the Business Incentive program for Fiscal Years 2014 and 2015 included:

- Verify and adjust the gross electric energy and demand (summer peak and winter peak) savings of the projects.
- Compare the adjusted gross savings with the claimed savings. The evaluation team began with the understanding that this comparison would have a prospective application emphasizing the Technical Reference Manual (TRM) assumptions, and that the assumptions might require future modification or additional research.
- Analyze the cost-effectiveness of the program and measures based on the Total Resource Cost Test (TRC) and the Program Administrator Cost Test (PAC).

To achieve these goals, Nexant evaluated the net and gross energy impacts through a combination of engineering analyses and on-site inspections of completed projects. Because it is not cost-effective to complete analysis and site inspection on a census of the implemented projects, the evaluation team verified energy savings for a representative sample of projects to draw statistically measurable results. The gross program-reported savings were adjusted by a realization rate, which is the ratio of evaluation-verified savings to the program-reported savings within the sample. Realization rates were determined for each of the four strata through measurement and verification of energy-efficient technologies installed within Efficiency Maine participating premises.

The net savings, which are an estimate of the portion of savings achieved as a direct result of program influence, were calculated by applying net-to-gross (NTG) scaling factor to the gross program-reported savings. To estimate NTG factors, the evaluation team employed participant surveys to quantify the actual impacts of the programs.

Nexant evaluated a sample of 98 projects distributed across all 4 strata, including desk reviews for all evaluated projects, telephone verification surveys with 30 of those participants and onsite measurement and verification for 68 of those sampled participants. Section 2.2 summarizes the audit, inspection, and survey methods used in the calculation of net and gross program energy impacts.

1.3 Impact Evaluation Results

A primary evaluation goal was to verify and adjust the gross electric energy and demand (summer peak and winter peak) savings of the projects. The evaluation team completed measurement and verification (M&V) of a sample of projects. A realization rate, which is the calculated ratio of the savings verified by Nexant (“ex-post”) to the savings reported by Efficiency Maine (“ex-ante”) for the projects within the sample, was calculated for each stratum. A value of 100% indicates that Efficiency Maine and Nexant calculated the savings consistently; a value of less than 100% indicates that the reported savings are overstated; a value of greater than 100% indicates that the reported savings are understated. Nexant applied each stratum’s realization rate to the total reported savings of the stratum to find the associated gross savings. The sum of each stratum’s gross savings is the program’s total gross savings. The methodology followed for obtaining these results is detailed further in Section 2.2. Table 1-2 provides a summary of the realization rates observed for energy and demand savings.

Table 1-2: Summary of Calculated Realization Rates

Stratum	Energy	Summer Demand	Winter Demand
Custom rebates (CR)	86.6%	101.3%	81.2%
Ductless heat pumps (DHP)	42.0%	42.0%	42.0%
Prescriptive lighting (PL)	88.7%	75.7%	61.2%
Prescriptive non-lighting (PNL)	112.2%	95.9%	73.7%
BIP Weighted Total	**90.4%**	**79.3%**	**63.5%**

Table 1-3 summarizes EMT’s BIP gross energy and demand impacts with the applied realization rates.

Table 1-3: Gross Impact Evaluation Key Results

Stratum	Verified Gross Energy Savings (kWh)	Verified Gross Summer Demand Savings (kW)	Verified Gross Winter Demand Savings (kW)
Custom rebates (CR)	6,739,399	991	1,083
Ductless heat pumps (DHP)[1]	-35,819	-48	122
Prescriptive lighting (PL)	74,654,800	9,230	8,073
Prescriptive non-lighting (PNL)[2]	8,943,455	1,101	847
BIP total	**90,301,835**	**11,274**	**10,126**

[1]DHP savings appear negative because they often pertain to measures in which gas heating equipment was removed and electric heating equipment was installed.

[2]One enrollment has been removed from the prescriptive non-lighting population. The project was erroneously submitted into one of the prescriptive non-lighting programs but should have undergone custom evaluation. The realization rate was of this project alone was found to be 3,000%

In general, net impacts are a reflection of the degree to which the gross savings are a result of the program efforts and funds. Nexant calculated the net savings by applying a NTG ratio to the gross savings. The scaling factor, along with the gross savings, were developed using random sampling methods to select and survey representative projects. The resulting net energy and demand impacts are presented in Table 1-4.

Table 1-4: Net Impact Evaluation Key Results

Stratum	Net-to-Gross Ratio	Verified Net Energy Savings (kWh)	Verified Net Summer Demand Savings (kW)	Verified Net Winter Demand Savings (kW)
Custom rebates (CR)	0.77	5,189,337	763	834
Ductless heat pumps (DHP)	0.69	-24,715	-33	84
Prescriptive lighting (PL)	0.76	56,737,648	7,015	6,135
Prescriptive non-lighting (PNL)	0.49	4,382,293	539	415
BIP total	**0.72**	**65,017,321**	**8,117**	**7,290**

1.4 Cost-Effectiveness Results

This report contains estimates of program cost effectiveness in accordance with the California Standard Practice Manual (CSPM) via the PAC and TRC test methods. The TRC test measures the costs of the program to society as a whole by including both the participant and utility costs; the PAC measures the costs of the program from the program administrator's point of view by only including those costs incurred by the program administrator. A TRC ratio of greater than one is considered cost-effective to society; a PAC ratio of greater than one is considered cost-effective to the program administrator. Table 1-5 summarizes the results of the cost-effectiveness assessments.

Table 1-5: Cost-Effectiveness Summary

Stratum	Gross Results	Net Results
PAC		
Custom rebates	6.01	4.33
DHPs	1.31	1.06
Prescriptive lighting	3.25	2.47
Prescriptive non-lighting	10.17	5.18
BIP total	**3.53**	**2.58**
TRC		
Custom rebates	2.08	1.91
DHPs	0.56	0.51
Prescriptive lighting	1.75	1.49
Prescriptive non-lighting	6.62	4.50
BIP total	**1.81**	**1.52**

1.5 Findings and Recommendations

In general, Nexant found that Efficiency Maine's Technical Reference Manual (TRM) accurately estimated the reported savings for most measures. Specific opportunities for improvement within the 2015 TRM include:

- Nexant observed that the assumed costs for lighting measures (Appendix E of the TRM) varied widely in accuracy. A comparison of the deemed costs with the invoiced costs for all lighting measures resulted in realization rates as low as 57% and as high as 1,003%. When Nexant analyzed the realization rates across the whole program and weighted them by incentive dollars contributed to the program, the overestimations and the underestimations averaged out to a realization rate of 113%. This rate meant that, in general, the costs in the TRM are understated, causing overstated TRC ratios. Nexant only completed this analysis for the prescriptive lighting stratum, but recommends that, in future program years, Efficiency Maine more thoroughly research the assumed costs associated with all TRM measures for accuracy of the TRC ratios. Further explanation of Nexant's analysis can be found in Section 3.3.2. Efficiency Maine did a full review of the TRMs when it relaunched the program after certain measures were suspended.

- Prescriptive measures include technologies that offer energy savings that can be accurately predicted, across applications, with limited input from the applicant. For these measures, Efficiency Maine uses industry standards and secondary research to assign deemed values to variables that directly affect the reported savings. This approach is typical of DSM programs, nationwide, and is acceptable for most parameters in the prescriptive measure programs. However, several parameters within Efficiency Maine's TRM were found to not be ideal candidates for this type of evaluation because they do not typically present with consistency across applications—for example, deemed wattages of installed light-emitting diode (LED) fixtures in the prescriptive lighting program and deemed sizes of installed fan motors in the prescriptive refrigeration program can vary widely from project to project. Since the 2015 TRM, Efficiency Maine has refined lighting bins in its TRM to reduce variability and fan motors are no longer an active measure.
- Efficiency Maine's algorithm for calculating energy savings from lighting retrofits included a term designed to capture the interactive effects on HVAC equipment, the factor was set to "1" for all measures. This factor could vary based on lighting equipment type, HVAC conditions and efficiencies, heating fuel type, and air temperature if Maine specific data is available. Recent studies in other jurisdictions found that these interactive effects can influence the demand savings by up to 23%, and the energy savings by up to 7%. This recommendation has already been satisfied as subsequent iterations of the TRM include more updated waste heat factor values.
- Winter demand realization rates were lower than summer demand realization rates across each stratum with the exception of ductless heat pumps, as detailed in Section 2.2.3. The difference in achieved winter and summer demand impacts is attributed to the high rate of seasonality found across businesses in Maine. There are a relatively high percentage of tourism-related businesses within the state that shut down operations for several months during the winter. Efficiency Maine has remedied this issue by modifying subsequent programs to exclude participation of seasonal businesses.

2 Methodology

Efficiency Maine's Business Incentive Program (BIP) provided education, technical assistance, quality control, and financial incentives to encourage a wide range of energy-efficiency (EE) projects in commercial and industrial buildings throughout Maine. The program offered both prescriptive incentives and custom incentives for energy-efficient upgrades to lighting; heating, ventilation, and air conditioning (HVAC); variable frequency drives (VFD); refrigeration; compressed air; and agricultural systems.

To determine the savings achieved by BIP, Nexant evaluated the net and gross energy impacts through a combination of engineering analyses and on-site inspections of completed projects. Because it is not cost-effective to complete analysis and site inspection on a census of the implemented projects, the evaluation team verified energy savings for a representative sample of projects to draw statistically measurable results. For the net-to-gross evaluation activities, Nexant interviewed participants and qualified partners (QP's) of the Business Incentive program. Nexant also interviewed program staff internal to Efficiency Maine.

2.1 Program Participation

Efficiency Maine's BIP provided education, technical assistance, quality control, and financial incentives to encourage a wide range of energy-efficiency projects in commercial and industrial buildings throughout Maine. Projects that qualified for more than $5,000 of incentives required pre-approval. The program offered both prescriptive incentives and custom incentives.

Prescriptive incentives were available for projects that save electricity through lighting, DHPs, HVAC, VFDs, refrigeration, compressed air, and agricultural equipment upgrades. Approximately 95% of program-sponsored projects were prescriptive.

Custom incentives were available for projects expected to result in energy savings, but were not eligible for prescriptive incentives because the project was too large or too complex. Costs and savings associated with custom projects vary by application and are generally large; to be eligible for non-prescriptive incentives, the project must have resulted in annual energy savings of 35,000 kWh or more. Custom incentives for retrofit projects were capped at 50% of the total cost of the efficiency project including labor, and at $0.28 per first year of kWh saved.

Participation in the Fiscal Years 2014 and 2015 Business Incentive Program totaled 8,004 unique enrollments with savings of almost 100 GWh. Table 2-1, Table 2-2, and Figure 2-1 summarize the 2014 and 2015 BIP energy and demand program impacts by measure and strata.

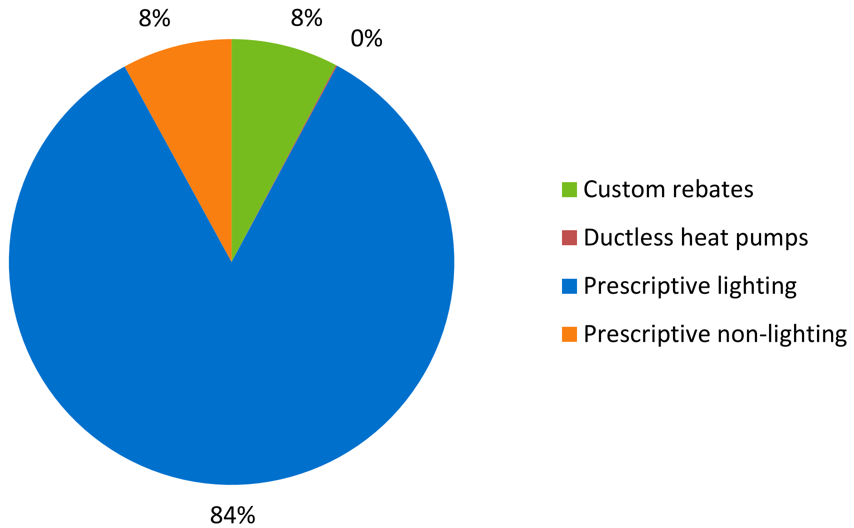
Table 2-1: 2014-2015 BIP Program Reported Energy and Demand Savings by Program

Program	Number of Enrollments	Ex-Ante Savings (kWh)	Ex-Ante Savings - Summer (kW)
Custom Compressed Air	10	1,286,227	165
Custom HVAC	5	586,719	96
Custom Lighting	29	2,284,247	580
Custom Misc	15	2,758,238	856
Custom VFD	3	863,212	83
Prescriptive Agriculture	14	663,144	178
Prescriptive Compressed Air	75	2,866,644	658
Prescriptive Ductless Heat Pump – Retrofit	486	-85,228	110
Prescriptive HVAC	167	819,678	491
Prescriptive Lighting New Construction	649	18,378,942	4,538
Prescriptive Lighting Retrofit	6,418	65,824,901	17,240
Prescriptive Refrigeration	90	769,244	106
Prescriptive VFD	43	2,857,443	387

Table 2-2: 2014-2015 BIP Program Reported Energy and Demand Savings by Strata

Stratum	Ex-Ante Energy Savings (kWh)	Ex-Ante Summer Demand Savings (kW)	Ex-Ante Winter Demand Savings (kW)
Custom rebates (CR)	7,778,643	978	1,334
Ductless heat pumps (DHP)	-85,228	-115	290
Prescriptive lighting (PL)	84,203,844	12,201	13,184
Prescriptive non-lighting (PNL)	7,968,416	1,148	1,150
Total	**99,856,674**	**14,213**	**15,958**

Figure 2-1: 2014-2015 BIP Program Reported Energy Shares by Strata



2.2 Impact Evaluation

The primary determinants of impact evaluation costs are the sample size and the level of rigor employed in collecting the data used in the impact analysis. The accuracy of the study findings is in turn dependent on these parameters. Techniques that Nexant used to conduct the evaluation, measurement, and verification (EM&V) activities, and to meet the goals for this evaluation, include on-site inspections and measurements, telephone surveys, documentation review, secondary data source review, interviews with program participants.

The impact evaluation generally encompassed the following steps, which are described in further detail throughout this report:

- **Design the Sample for Measurement and Verification (M&V):** Review and M&V of all implemented projects is not plausible or cost-effective given the size of these programs. Consequently, a sample of projects was established for measurement and verification, which consisted of four strata of like projects.
- **Develop Program/Measure-Specific M&V Plans:** Upon review of the program documents, a unique M&V plan was developed for each program and measure, including a metering protocol, as applicable. M&V methods for each measure type were developed with adherence to the International Performance Measurement and Verification Protocol (IPMVP).
- **Participant Surveys and On-site Inspections:** The file review for all sampled and reviewed projects included a desk review with a telephone survey with the participant. For a portion of the reviewed projects, on-site audits and measurement further detailed the information obtained during the file review necessary to calculate energy savings.
- **Calculate Impacts and Analyze Load Shapes:** Data collected via the on-site visits, desk reviews, and telephone surveys enabled the evaluation team to calculate gross verified energy and demand savings for each project or measure. Hourly load shapes

are important in calculating system on-peak demand savings, especially when the measures installed have daily and seasonal variations in the operating schedule.

- **Estimate Net Savings**: Net impacts are a reflection of the degree to which the gross savings are a result of the program efforts and funds. The evaluation team estimated free-ridership and spillover for each project in the impact sample utilizing self-report methods through surveys with program participants. The ratio of net verified savings to gross verified savings is the net-to-gross ratio as an applied scaling factor to the reported savings.

Total program gross savings are adjusted using the following equation:

Equation 1: Algorithm for Total Gross Energy Savings

$$kWh_{adj} = kWh_{rep} \cdot Realization\ Rate$$

Where:

kWh_{adj} = kWh adjusted by the impact team for the program, the gross impact

kWh_{rep} = kWh reported for the program

Realization rate = weighted average kWh_{adj} / kWh_{rep} for the research sample

Demand (kW) savings are treated in a similar manner with realization rates being calculated separately for the winter and summer peak windows.

2.2.1 Basis for Reported Savings

The Efficiency Maine Technical Reference Manual (TRM) contains the algorithms and assumptions of each measure offered within the program. Efficiency Maine also programmed the algorithms and assumptions into their online tracking and reporting database “effRT”, updating them as the TRM gets revised. Upon opening an enrollment, the applicant designates the equipment type utilized in the project. effRT looks up the corresponding algorithm and assumptions, and requires the user to insert any variables that the TRM does not deem. For example, the 2015 TRM provides the following equation for interior lighting fixture retrofits:

Equation 2: Algorithm for Reported Energy Saving Estimates

$$kWh/yr = \frac{[\,Qty_{BASE} \cdot Watts_{BASE} - \ Qty_{EE} \cdot Watts_{EE}]}{1{,}000} \times HoursWk \times Weeks \times WHF_e$$

Table 2-3 summarizes the source location for each parameter in Equation 1.

Table 2-3: Source Location of Reported Energy Saving Input Parameter - Example

Qty Base	Quantity of removed fixtures	Source Location
Watts Base	Wattage of removed fixtures	TRM-deemed
Qty EE	Quantity of installed fixtures	User specified
Watts EE	Wattage of installed fixtures	TRM-deemed
HoursWk	Weekly hours of equipment operation	User specified
Weeks	Annual weeks of equipment operation	User specified
WHF	Waste heat factor	TRM-deemed

An applicant applying for this measure would be prompted to input the following into effRT:

- Existing fixture description
- Existing quantity
- Installed fixture description
- Weekly hours of operation
- Weeks per year

effRT would then populate the algorithm with the corresponding values, drawing from the applicant inputs and the library of TRM-deemed assumptions, in order to calculate the reported energy savings, which are saved to the database at the time savings are calculated. As assumptions are updated within the TRM, algorithms are also changed in the stored library within effRT. Changes to assumptions only affect new applications that come in after the updates; changes do not retroactively affect projects with stored energy savings values.

2.2.2 Prescriptive Lighting

Nexant used an Excel template for lighting measures to collect field data, where applicable, and calculate savings. The tool was designed to accommodate multiple combinations of both TRM-based and custom-control strategies (described by an "SVG" factor), hours of use (HOU), coincidence factors (CF), and waste-heat factors (WHF), across different measures within one project. A brief overview of the tool's functionality is described below:

- Customer inputs recorded in effRT were transferred into the workbook by a Nexant engineer. The workbook replicated the reported savings as presented in effRT.
- A parallel calculation was completed using Nexant's revised inputs as discovered through the project file review, phone interview, or on-site inspection.
- HOU and CF were calculated by one of two methods. Initially, each calculator was populated with self-reported operating hours including holiday and seasonal schedules as obtained through customer interviews. If collected, metered hours of use was incorporated into the analysis. Analysis of logger data consisted of creating an 8,760-hour load shape for the logged piece of equipment, which dictated the logged fixture's

hours of use, summer and winter coincidence factors, and energy period factors. For exterior photocell-controlled lighting, historical sunrise and sunset data was used in lieu of logger data to estimate pre- and post-retrofit energy consumption. In the event a site was logged, the HOU and CF determined by the logger override the self-reported schedules.

- The reported savings and verified savings were compared side by side to calculate the project-level realization rate.

One data collection and calculation file was created for each of the sampled prescriptive lighting projects. A supplemental roll-up tool was created to extract and compile the ex-ante savings, ex-post savings, and weighted key assumptions (HOU and CF) from each project-level analysis.

Nexant's roll-up tool extracted each project's calculated or observed HOU and CF values. The values were weighted by each line item within each calculator. Observed HOU values were weighted based on each line item's kWh savings contribution; observed CF values were weighted by each line item's kW savings contribution. The project-level averages were then weighted again by project-level savings contribution to create portfolio-level assumptions for comparison to EMT's TRM. The process is depicted using winter CF as an example in Figure 2-2.

Figure 2-2: Weighted Coincidence Factor Methodology

Space-specific coincidence factors are calculated for each measure according the the customer's account of when the lights are operational in the space.

Customer-Supplied Schedule		
Measure	Weekday Lights On	Weekday Lights Off
Measure 1	9:00 AM	3:00 PM
Measure 2	9:00 AM	5:00 PM
Measure 3	4:00 PM	10:00 PM
Measure 4	9:00 AM	4:30 PM

Calculation of Summer Demand					
Hour:	1:00 PM	2:00 PM	3:00 PM	4:00 PM	CF_S
% of time on	1.0	1.0	0.0	0.0	50%
% of time on	1.0	1.0	1.0	1.0	100%
% of time on	0.0	0.0	0.0	1.0	25%
% of time on	1.0	1.0	1.0	0.5	88%

Each line item is pre-populated with the site-specific calculated coincidence factor. This coincidence factor is overriden with logger data where available.

(1 Logger Deployed)		
Measure	Savings (kWh)	CF
Measure 1	50	0.50
Measure 2	150	1.00
Measure 3	500	0.25
Measure 4	100	0.90

(2 Loggers Deployed)		
Measure	Savings (kWh)	CF
Measure 1	50	0.50
Measure 2	150	0.85
Measure 3	500	0.45
Measure 4	100	0.88

(No Loggers Deployed)		
Measure	Savings (kWh)	CF
Measure 1	50	0.50
Measure 2	150	1.00
Measure 3	500	0.25
Measure 4	100	0.88

A weighted coincidence factor is created for each enrollment as the sumproduct of the line item savings and its CF divided by the total enrollment savings.

Weighted CF: 0.49

Weighted CF: 0.58

Weighted CF: 0.48

The stratum-wide weighted coincidence factor is created as the sumproduct of each enrollment's savings and its CF divided by the total sample savings.

Stratum-Wide		
Enrollment	Savings (kWh)	CF
Enrollment 1	800	0.49
Enrollment 2	800	0.58
Enrollment 3	800	0.48
	Weighted CF:	0.52

This process was completed for interior and exterior fixtures separately, to appropriately mimic the EMT TRM. The TRM also specifies CF assumptions for refrigerated case lighting, lighting controls, and refrigerated case lighting controls. However, there were not enough instances of these measure types in the sample to create specific values for each.

Once program-wide CF values were calculated, the verified summer and winter demand savings were calculated for the sample as the sum of the change in connected load across all 66 projects multiplied by the Nexant-derived coincidence factor. This is analogous to the application of EMT's TRM as CF values are not open for user-input, but rather are deemed based on values pre-determined to be the best fit for the majority of applicants.

While Nexant did calculate an appropriate program-wide HOU value, the total energy savings for the sample were calculated as the sum of the individual energy savings recorded within each project-level calculator. This is comparable to the TRM calculation as the TRM requires the applicant to specify their own HOU rather than using a single deemed value for all applicants.

The ratio of the ex-post to ex-ante savings observed in the 66-project sample was set as the realization rate for the prescriptive lighting stratum. This realization rate was then applied to the population reported savings to determine the verified gross savings.

2.2.3 Ductless Heat Pumps

Over the course of the evaluation period, the TRM algorithm and the assumptions surrounding ductless heat pumps went through a variety of changes as Efficiency Maine worked to continually improve the program offering. Furthermore, as discussed previously, retrofit ductless heat pump measures are unique in that they often provided an increase in electric energy usage as a tradeoff for reduced alternate fuel consumption (typically natural gas). Given the volatility of this particular measure over the course of the evaluation period, Nexant and Efficiency Maine agreed that it would be most appropriate to quantify energy impacts in kBtu moved, as opposed to electric energy savings (kWh). Nexant created a Microsoft Excel tool to facilitate these calculations, the functionality of which is described briefly below:

- Customer inputs recorded in effRT were transferred into the workbook by a Nexant engineer. The workbook replicated the TRM-based reported savings as presented in effRT.
- A Nexant on-site engineer obtained thermostat setpoints, setbacks, and operating schedules, and then input those parameters into the workbook to create an 8,760-hour profile of the expected indoor air temperature.
- Hourly amp logging data was input into the workbook for comparison against the unit in question's capacity correction curve. The capacity correction curve specified the unit's maximum power draw and corresponding heating or cooling capacity, based on the indoor and outdoor air temperatures. The hourly kBtu moved for each system was estimated using Equation 3.

Equation 3: kBTU Moved by Ductless Heat Pump

$$kBTU\ Moved = \frac{Logged\ Power}{Full\ Load\ Power} * Full\ Load\ Capacity$$

Where:

Logged Power = True RMS power (kW) measured in the field with system running

Full Load Power = Rated full load power (kW) of DHP system

Full Load Capacity = Rated cooling or heating capacity of the DHP system in kBtu/hr

- A regression was created of the kBTU moved as a function of both indoor and outdoor air temperature, which was then applied to a typical meteorological year (TMY) weather data to determine the annual kBTU moved by the equipment.

Each data collection and calculation template represented only one piece of equipment installed, even though many projects involved multiple units; thus, project-level savings were calculated individually based on available data and supplemented with TRM-based calculations when required. For example, if one project involved two 3-ton heat pumps and one 4-ton heat pump and only one of the 3-ton heat pumps was sub-metered, then savings would be calculated as two times the results of the 3-ton heat pump logger analysis plus an additional TRM-based savings estimate for the unlogged 4-ton heat pump system.

Once project-level savings were determined, a supplemental roll-up file was created to extract and compile the TRM-based and field-observed kBTU moved from each analysis. The realization rate for the equipment was taken as the observed kBTU moved by the equipment for the year, compared to the TRM-calculated kBTU moved. This realization rate was then applied to the project population–reported kWh and kW savings to determine the verified gross savings.

2.2.4 Prescriptive Non-Lighting

The sampled prescriptive non-lighting projects included HVAC, compressed air, refrigeration, and VFD measures. There was only a limited number of each of these different measures, so no standard calculators were made for the prescriptive non-lighting stratum. Custom data collection and calculation tools were designed for each project using the measure-specific TRM algorithm.

Project-level data was obtained from effRT and input into each custom calculator. A Nexant engineer then reviewed all project documentation, including invoices and cut sheets, and flagged areas of concern in the calculator. Each project then received either a telephone survey and desk review, or an on-site inspection to verify the flagged parameters. For sites that only received a desk review, participants were asked via phone interview about the flagged items in the calculator. For sites that received an on-site inspection, flagged areas of concern were inspected by a field engineer. Changes to the ex-ante assumptions were recorded in a separate tab of the calculator. All prescriptive non-lighting projects that received an on-site inspection also included installation of amp loggers for a period of up to 6 months to confirm the hours of use and coincidence factors of the key pieces of equipment and retrofitted areas.

Once each data collection and calculation tool was complete, a roll-up file was created to extract and compile the ex-ante and ex-post savings from each file. The ratio of the ex-post to ex-ante savings observed across all measure types in the 11-project sample was set as the realization rate for the prescriptive non-lighting stratum. This realization rate was then applied to the project population–reported savings to determine the verified gross savings.

2.2.5 Custom Rebates

The sampled custom rebates projects included HVAC, lighting, compressed air, refrigeration, and chiller measures. The four lighting projects within the sample were analyzed using the prescriptive lighting calculator. Because there was only a limited number of each of the remaining measures, no standard calculators were made for the custom rebates stratum. Rather, custom data collection and calculation tools were designed by a Nexant engineer for each remaining project. When applicable and available, calculators were designed to analyze 8,760-hour load shapes of installed equipment.

Project-level data was obtained from effRT and input into each custom calculator. A Nexant engineer reviewed all project documentation, including invoices, savings calculations, and cut sheets, flagging areas of concern in his or her calculator. Each project then received either a telephone survey and desk review, or an on-site inspection to verify the flagged parameters. For sites that received a desk review, participants were asked via phone interview about the flagged items in the calculator. For sites that received an on-site inspection, flagged areas of concern were inspected by a field engineer. Changes to the ex-ante assumptions were recorded in a separate tab of the calculator. When available, the field engineer obtained trending data from the site contact. In other situations, amp loggers were installed for a period of up to 6 months in order to confirm the hours of use and coincidence factors of the key pieces of equipment and retrofitted areas.

Once each data collection and calculation tool was complete, a roll-up file was created to extract and compile the ex-ante and ex-post savings from each file. The ratio of the ex-post to ex-ante savings observed across all measure types in the 10-project sample was set as the realization rate for the custom rebates stratum. This realization rate was then applied to the project population–reported savings to determine the verified gross savings.

2.2.6 Net-to-Gross Methodology

Net savings are the savings directly attributable to a program and account for the actions that the participant would have taken in absence of the program (freeridership) and the actions taken by a participant outside of the program incentive (spillover). A program net-to-gross ratio (NTG) equals the net program energy impact divided by the gross program energy impact. Nexant derived net savings by adjusting the realized gross energy-savings estimates to account for freeridership and spillover. These adjustment factors are consistent with the State and Local Energy Efficiency Action Network Program Impact Evaluation Guide[1] and the chapter on net savings in the Uniform Methods Project (UMP).[2]

To assess the impact of a program, evaluators generally consider freeridership and spillover.. For this evaluation, Nexant used the definition of the NTG ratio as shown in Equation 4:

Equation 4: Net-to-Gross Calculation

$$NTG = 1 - Freeridership + Spillover$$

Freeridership refers to a participant who, on some level, would have acquired the energy-efficient equipment or taken action to reduce their energy use in the program's absence. The effect of freeriders reduces the gross savings attributable to the program.

[1] State and Local Energy Efficiency Action Network. Energy Efficiency Program Impact Evaluation Guide. December 2012.

[2] Under the UMP, the U.S. Department of Energy is preparing a framework and set of protocols for determining the energy savings from specific energy efficiency measures and programs. These protocols present methods for evaluating gross energy savings for common residential and commercial measures offered through utility demand-side management (DSM) programs, and are written by technical experts within the field and reviewed by industry experts. (https://www1.eere.energy.gov/office_eere/de_ump.html)

Spillover refers to actions taken outside the program that reduce energy use, which are attributable to program participation. The evaluation team added spillover energy savings attributable to the program in the net savings estimate.

2.2.6.1 Approach to Estimating Participant Freeridership

The overall freeridership score was derived from two independently calculated elements, each of which is worth half of the total score: a stated intent/project change score and an influence score. These scores were calculated based on answers to questions that address two main components: how the project would have changed in the absence of the program (postpone or cancel project, reduce size or scope of project, choose less efficient equipment, or no change) and the influence of various program features on participation (incentives, marketing, technical assistance, Qualified Partner recommendation.) For contacts reporting that they would not have done anything different in absence of the program, the stated intention question is further checked by a question about whether the respondent's firm would have made funds available to cover the entire cost of the project. The score for the most influential element was taken as the influence score component of the total freeridership score.

Each element (stated intention and program influence) produced a range of freeridership values from 0 to 0.5 and were added together to produce a total freeridership score ranging from 0 (not a free-rider) to 1.00 (full free-rider).

2.2.6.2 Approach to Estimating Participant Spillover

Participant spillover questions seek to understand if the customer invested in additional energy-efficiency measures for which they did not receive any Efficiency Maine incentives. The participant survey also asked for additional metrics that would enable Nexant to estimate attributable savings to these measures. Participant spillover savings were included based on: 1) survey responses indicating the installation of additional measures, and 2) the ability to quantify those savings.

The steps Nexant took to determine total program spillover were:

1) Calculate total spillover savings for each participant as the sum of quantifiable measure savings, multiplied by the number of units, as shown in Equation 5.

Equation 5: Measure Spillover

$$= Quantifiable\ Measure\ Savings\ \times Number\ of\ Units$$

2) Total the savings associated with each program participant to calculate the overall participant spillover savings, as shown in Equation 6.

Equation 6: Participant Spillover

$$= \sum Total\ Survey\ Sample\ Spillover\ kWh\ Savings$$

3) Multiply the mean participant spillover savings for the sample by the total number of participants to estimate total participant spillover savings for the program, as shown in Equation 7.

Equation 7: Spillover kWh Savings Extrapolated to the Participant Population

$$= \frac{\sum Survey\ Sample\ Spillover\ kWh\ Savings}{Sample\ Size\ (n)} \times Program\ Participant\ Population$$

4) Divide the total participant spillover savings by the total program savings to yield a participant spillover percentage for inclusion in calculating the NTG ratio, as shown in Equation 8.

Equation 8: Spillover Percentage Estimate

$$= \frac{\sum Spillover\ kWh\ savings\ extrapolated\ to\ the\ participant\ population}{Evaluated\ program\ population\ kWh\ Savings}$$

2.2.6.3 Net-to-Gross Error Estimation

Relative precision is calculated as the margin of error over the point estimate mean NTG value of each measure category, as outlined in Equation 9 through Equation 11.

Equation 9: Standard Error of the Mean

$$= \frac{Standard\ Deviation\ of\ the\ Sample}{\sqrt{(Sample\ Size)}}$$

Equation 10: Margin of Error

$$= z - value\ at\ 90\%\ confidence^{1} \times Standard\ Error\ of\ the\ Mean$$

Equation 11: Relative Precision

$$= \frac{Margin\ of\ Error}{Sample\ Mean}$$

2.3 Sampling

The sample frame for the evaluation included projects completed between July 1, 2013 and June 30, 2015. The following sections outline the sample approach for the impact evaluation and discuss the presentation of uncertainty in the findings.

2.3.1 Impact Evaluation Sample Approach

In evaluating Efficiency Maine’s Business Incentive Program, Nexant looked specifically at a sample of project participants across the program. When a representative sample is selected and analyzed, the evaluation team can extrapolate the sample statistics to provide a reasonable estimate of the project population parameters. Therefore, when used effectively, sampling can improve the overall quality of an evaluation study. The alternative would have been a census

[1] Z=1.645

evaluation approach, which would have involved surveying, measuring, or otherwise evaluating all projects within a population. A census approach would have eliminated sampling uncertainty, but it is resource-intensive for both the evaluation team and participating customers. By limiting the resource-intensive data collection and analysis to a random sample of all projects, the evaluation team was able to pay more attention to each project surveyed.

Nexant applied several objectives across the sampling effort. The most important objective was representativeness: the projects selected in the evaluation were representative of the project population and produced unbiased estimates of population parameters. A second objective was to consider the value of the information being collected—for example, the amount of the savings and uncertainty associated with the study area—and then allocating the appropriate level of evaluation resources.

Nexant used ratio estimation, or estimation using auxiliary information, to make inferences about program or stratum performance based on observations and measurements collected from the evaluation sample. This technique assumed that the ratio of the sum of the verified savings estimates, to the sum of the reported savings estimates, is representative of the program as a whole. This ratio is referred to as the *realization rate*, or *ratio estimator*, and is calculated as presented in Equation 12.

Equation 12: Calculating Realization Rates

$$Realization\ Rate = \frac{\sum_i^n Verified\ Savings}{\sum_i^n Reported\ Savings}$$

Where *n* is the number of projects in the evaluation sample. The realization rate is then applied to the claimed savings of each project in the project population to calculate gross verified savings.

2.3.1.1 Stratification

Nexant used two different types of random sampling in this evaluation. In simple random sampling, each sampling unit (customer/project/rebate/measure) has an identical likelihood of being selected in the sample. In stratified random sampling, two or more sub-groups, or strata, are identified from within a program population before the selection process. The probability of selection was different between strata and this difference must be accounted for when calculating results. The inverse of the selection probability is referred to as the “case weight”; evaluators use case weight when estimating impacts from stratified random samples. When using stratified random sampling, Nexant took great care to ensure that each sampling unit within the population belonged to no more than one stratum.

Table 2-4 shows a simplified example of stratified random sampling, based on a fictional program with two measures: LED exit signs and LED flood lights. Because exit signs were sampled at a lower rate (1-in-200) than floodlights (1-in-20), each sample point carries less weight in the overall program results than an individual floodlight sample point. In general, Nexant designed samples so that strata with high case weights had low per-unit impacts or were well-understood measures, such as prescriptive lighting. Low case weights were reserved for large and complex measures, such as custom rebates and ductless heat pumps.

Table 2-4: Fictional Case Weights Example

Measure	Population Size	Sample Size	Case Weight
LED exit signs	6,000	30	200
LED floodlights	600	30	20

2.3.1.2 Business Incentive Program Impact Sample

Efficiency Maine provided Nexant with log-in credentials to their online portal, "Efficiency Maine Reporting & Tracking System" (effRT). Nexant pulled a full list of participating enrollment numbers in BIP, and then looked up all of the corresponding participant information to create a full list of participants and projects. The list was then collapsed to only show one project per installation address. The gross impact sample was selected at random from this collapsed list. Table 2-5 presents the targeted and achieved design for the gross impact evaluation sample. The sample emphasized the ductless heat pump stratum and de-emphasized the prescriptive lighting measures, despite their respectively converse contributions to the total program savings. This design was chosen for two reasons. First, prescriptive lighting measures are well-researched and tend to show better alignment between estimated and verified savings, and therefore require fewer resources to analyze. Second, ductless heat pump measures often replace delivered fuel heating systems, making the total energy savings associated with the technology *appear* negative. The evaluation team chose to sample this measure more heavily to thoroughly study the performance of this dynamic measure.

Table 2-5: Estimated and Achieved Gross Impact Samples by Stratum

Measure Category	Share of Program Savings	Achieved Sample Size
Custom rebates (CR)	8%	10
Prescriptive lighting (PL)	84%	66
Prescriptive non-lighting (PNL)	8%	11
Ductless heat pump (DHP)	0%	11
Program Total Sample Size		**98**

Table 2-6 shows the targeted and achieved distributions of primary data collection activities across the 98 sample points. Additional detail on each of the gross impact data collection activities is presented in Section 2.2.

Table 2-6: Target and Achieved Gross Impact Samples by Verification Approach

Primary Data Collection Activity	Number of Target Sites	Number of Achieved Sites
Telephone surveys	32	30
Custom rebates (CR)	4	2
Prescriptive lighting (PL)	22	21
Prescriptive non-lighting (PNL)	6	7
Site inspections	40	42
Custom rebates (CR)	6	8
Prescriptive lighting (PL)	18	19
Prescriptive non-lighting (PNL)	5	4
Ductless heat pumps (DHP)	11	11
Logging of key parameters	56	61
Custom rebates (CR)	4	5
Prescriptive lighting (PL)	40	41
Prescriptive non-lighting (PNL)	2	4
Ductless heat pumps (DHP)	10	11

2.3.2 Presentation of Uncertainty

An inherent risk, or uncertainty, accompanies sampling: the projects selected in the evaluation sample may not be representative of the program population as a whole with respect to the parameters of interest. As the proportion of sampled projects increases, the amount of sampling uncertainty in the findings decreases. The amount of variability in the sample also affects the amount of uncertainty introduced by sampling. A small sample drawn from a homogeneous population will provide a more reliable estimate of the true population characteristics than a small sample drawn from a heterogeneous population. Variability is expressed using an error ratio for programs that use ratio estimation.

Equation 13 provides the formula for estimating error ratio.

Equation 13: Error Ratio

$$Error\ Ratio = \frac{\sum_{i=1}^{N} \sigma_i}{\sum_{i=1}^{N} \mu_i}$$

Equation 14 shows the formula used to calculate the required sample size, based on the desired level of confidence and precision. The error ratio term is in the numerator, so the required sample size will increase as the level of variability increases.

Equation 14: Required Sample Size

$$n_0 = \left(\frac{z * Error\ Ratio}{D}\right)^2$$

Where:

n_0 = The required sample size before adjusting for the size of the population

Z = A constant, based on the desired level of confidence (equal to 1.645 for 90% confidence two-tailed test)

Error Ratio = Measure of variability (analogous to the coefficient of variation in mean-per-unit estimation)

D = Desired relative precision

The sample size formula shown in Equation 14 assumes that the population of the program is infinite and that the sample being drawn is reasonably large. In practice, this assumption is not always met. For sampling purposes, any population greater than approximately 7,000 may be considered infinite for the purposes of sampling. For smaller, or finite, populations, the use of a finite population correction factor (FPC) is warranted. This adjustment accounts for the extra precision that is gained when the sampled projects make up more than about 5% of the program savings. Multiplying the results of Equation 14 by the calculated FPC will produce the required sample size for a finite population.

Throughout this report, gross and net verified energy and demand savings are reported together with the associated margin of error introduced by sampling. Verified savings estimates always represent the point estimate of total savings, or the midpoint of the confidence interval around the verified savings estimate for the program. The margin of error surrounding a particular parameter estimate is the product of the standard error of the parameter of interest and a z-statistic calculated based on the desired confidence level and standard normal distribution. For alignment with ISO-New England's M-MVDR 80/10 requirements, the confidence levels and precision values presented in this report are at the 80% confidence level. The z-statistic associated with 80% confidence is 1.28.

Use of a z-statistic implies normality. The Central Limit Theorem shows that the means of sufficiently large random samples drawn from a population will follow a normal distribution, even if the population that is the source of the sample is not normally distributed. However, for sample sizes smaller than 30, the Central Limit Theorem begins to break down and the normality assumption is no longer valid. A t-distribution is the appropriate distribution to consider when drawing samples of fewer than 30 projects/measures. In some instances of small sample size (usually stratum-level findings), Nexant used t-statistic in the precision estimate. In this situation, the t-statistic replaced the z-statistic in Equation 14 and was calculated using the degrees of freedom (sample size minus the number of estimates). As the sample size becomes larger, the t-statistic gets closer to the z-statistic.

This report consistently reports the relative precision value associated with verified savings estimates. When evaluators or regulators use the term "90/10", the 10 refers to the relative precision of the estimate. An important attribute of relative precision to consider when reviewing achieved precision values is that it is "relative" to the impact estimate. Therefore, programs with low realization rates are likely to have larger relative precision values because the error bound (in kWh or kW) is being divided by a smaller number. This means two programs with the same reported savings and sampling error in absolute terms, may have different relative precision values.

In many cases, a program-level savings estimate requires summing the verified savings estimates from several strata. To calculate the relative precision for these program-level savings estimates, Nexant used Equation 15 to estimate the error bound for the program, as a whole, using the stratum-level error bounds.

Equation 15: Combining Error Bounds across Strata

$$Error\ Bound_{Program} = \sqrt{Error\ Bound_{Stratum1}^2 + Error\ Bound_{Stratum2}^2 + Error\ Bound_{Stratum3}^2}$$

Using this methodology, Nexant developed verified savings estimates for the program and an error bound for that estimate. The evaluation team then calculated the relative precision of the verified savings for the program by dividing the error bound by the verified savings estimate.

2.4 Benefit-Cost Modeling

Efficiency Maine's online portal contains a module called the Cost Benefit Analysis Tool (CBAT), which is capable of running custom cost-benefit analyses based on multiple user inputs. Because of the sophistication of Efficiency Maine's tool, and the lack of project-level insight available to recreate it, Nexant opted not to create a parallel benefit-cost modeling tool. Instead, a rigorous evaluation of the tool was conducted, and Nexant ultimately used CBAT to run both the total resource cost (TRC) test and program administrator cost test (PAC).

2.4.1 CBAT Verification

CBAT is designed to provide a cost-benefit analysis for any number of programs through any date range using the following default schedules and user-defined inputs:

Programmed Values/Schedules

- Reported Savings
- Avoided energy costs
- Avoided capacity costs
- Line loss multiplier
- Incentive amounts
- Measure lives
- Incremental costs
- Measure-level energy period factors
- Measure-level realization rate
- Measure-level NTG ratios

User Inputs

- Test type (TRC or PAC)
- Savings type (Net or Gross)
- Date range of interest
- Discount rate
- Generation markup
- Program(s) of interest
- Appropriate avoided cost schedule

Before using the tool for cost-benefit analysis, Nexant performed a series of tests to verify the tool was properly incorporating all schedules and values. Efficiency Maine provided Nexant with its 2015 avoided-costs schedule, and a document containing step-by-step instructions concerning CBAT programming. Nexant also downloaded all current and historical factor schedules for the time period of the evaluation from effRT. Nexant used Efficiency Maine's instructions to recreate the CBAT calculations in Microsoft Excel for comparison, and performed tests using small windows of time that included fewer than five projects each for verification. Key input parameters (i.e. savings type and discount rate) were changed across test runs to find errors that could have been associated with particular inputs. As errors were found, Nexant worked with Efficiency Maine to have them corrected until the results showed less than 1% error in all benefit and cost categories. Table 2-7 shows the final results of the CBAT verification exercise.

Table 2-7: Errors Noted in CBAT Recreation

Benefit Type	Nexant Calculation	CBAT Calculation	% Difference
Total benefits	$3,139.30	$3,139.04	< 0.1%
Total costs	$1,929.79	$1,929.79	0%
TRC Ratio	1.63	1.63	< 0.1%

Nexant only found one error within the CBAT module as a result of this verification exercise. Originally, CBAT did not apply line losses to demand calculations, although it did appropriately include them for energy calculations. Nexant presented this issue to Efficiency Maine, and it was corrected.

In the midst of the evaluation, Efficiency Maine updated CBAT to allow for calculation of savings using multiple avoided cost tables should inputs span multiple years. After this update, Nexant again performed a verification of the tool. One error was found within one of the avoided cost tables, which was immediately corrected.

2.4.2 CBAT Adaptation for Evaluator Use

CBAT is designed to use summer and winter peak demand savings that are stored within effRT (as opposed to calculating them based on change in connected load and assigned coincidence factors). Although this was not a shortcoming of effRT, it created the need for a workaround to enable the use of Nexant's observed coincidence factors for the PL and DHP strata.

Utilizing the roll-up tools that were previously used to aggregate savings across each stratum, Nexant was able to create stratum-specific factor tables from the individual analysis workbooks. These factor schedules included realization rates, freeridership rates, and spillover rates for all strata, as well as coincidence factors and energy period factors for the PL and DHP strata. These factor tables were uploaded to override the default assumption schedules previously put in place by Efficiency Maine. Then, Nexant ran CBAT for each stratum separately, tabulating the benefits and costs of each run in a supplemental Microsoft Excel workbook.

As CBAT ultimately does not use the factor tables to calculate summer and winter kW at the time the module is run, additional steps were required in order to use the evaluator-developed coincidence factors for the prescriptive lighting and ductless heat pump strata. First, CBAT was run in “calculated” mode, which provided a report of the kWh, winter kW, and summer kW associated with each measure within the report. The report was then downloaded, and the summer and winter kW values were discarded. CBAT was then switched to “manual” mode, in which the user specifies the kWh, winter kW, and summer kW associated with each measure. Nexant populated these values with the kWh reported from the calculated run, and the winter and summer kW hours calculated based on reported measure-level kW savings with evaluator-derived coincidence factors applied. The benefits of these runs were then input into the supplemental Excel workbook replacing the previously recorded benefits.

The program costs had to be added into the supplemental Excel workbook as CBAT does not account for these costs when run at the program level. These costs can be entered into CBAT manually for inclusion, but will only be applied at the portfolio level. Nexant found the program costs for the two evaluation years in Efficiency Maine’s annual reports and allocated them to each stratum based on relative contribution of incentive dollars to the portfolio. Incentive dollars, as opposed to kWh savings, were used to weight the strata because of the negative savings associated with the ductless heat pump measures. With all of the components assembled, the final TRC and PAC ratios were calculated in Microsoft Excel.

3 Findings and Results

This section provides the summary of findings and results for the impact evaluation. Refer to section 2.3 for more information on the impact evaluation methodology.

3.1 Gross Impact Estimates

The first step of the impact evaluation was to determine the gross energy and demand savings associated with BIP. Nexant accomplished this by examining a sample of representative projects within each of the four strata. The accuracy of Efficiency Maine's reporting for the representative sample was applied to the population of projects within each stratum. Nexant developed the program-wide savings as the summation of the individual stratum savings. This section presents the results of the evaluation of the representative samples and Nexant's findings.

3.1.1 Energy Impacts

The realization rates and gross energy impact estimates calculated as described in Section 2.2 are presented in Table 3-1. In summary, BIP saved more than 90 million kWh in ex-post gross savings with a realization rate of 90%. The selected sample meets the estimated precision and confidence goals with ± 8% precision at the 80% confidence level.

Table 3-1: BIP 2014-2015 Gross Energy Impact Estimates

Stratum	Ex-Ante Savings (kWh)	Realization Rate (%)	Ex-Post Savings (kWh)	Relative Precision at 80% Confidence (%)
Custom rebates	7,778,643	86.6%	6,739,399	-
Ductless heat pumps	-85,228	42.0%	-35,819	-
Prescriptive lighting	84,203,844	88.7%	74,654,800	-
Prescriptive non-lighting	7,968,416	112.2%	8,943,455	-
Total	**99,865,674**	**90.4%**	**90,301,835**	**7.8%**

3.1.1.1 Custom Rebates

In general, the reported savings associated with the projects in the custom rebates stratum tended to be accurate. The low realization rate was a direct result of three projects each having a realization rate of less than 60%.

The first of these projects was a custom lighting project carrying a realization rate of 36%. Custom lighting projects used lighting power density (LPD) calculations to compare the efficiency of the lighting installed to a code-allowed wattage per square foot for the space type in question. In this instance, however, only a portion of the lights falling within the retrofitted square footage was included in the analysis. When using LPD calculations, all lighting present in the space must be accounted for, regardless of whether it is part of the retrofit or not; otherwise, the watts per square foot within the space will be understated, and the savings overstated. This was the case in this instance. This could be rectified by evaluating projects as a one-for-one retrofit, or by including the wattages of the remaining inventory of fixtures in the calculations. Nexant chose to analyze this project as a one-for-one retrofit, using the standard prescriptive lighting calculator as the full lighting inventory was unavailable.

The remaining two outliers in the custom rebates stratum resulted from discrepancies between the observed hours of operations, and the hours of operation quoted on the application. Each piece of equipment—an air compressor and a chiller—was projected to operate year-round. However, logging indicated that both pieces of equipment were only used as backups, with operating hours of less than 1,000 hours annually.

3.1.1.2 Ductless Heat Pump Findings

The low realization rate observed in the ductless heat pump stratum reinforces some of the motivations for changes that were implemented throughout the course of this evaluation. One major change was a reduction in the TRM-provided effective full-load heating hours ($EFLH_H$) assumption. The evaluation found the average $EFLH_H$ of the 15 sampled units to be approximately 1,904 hours per year, which supported EMT's decision to reduce the stipulated TRM assumption.

Of the 15 heat pump systems evaluated, eight had reported savings based upon the older TRM $EFLH_H$ value. The remaining seven had claimed savings based on a more recent TRM hours per year assumption. This had major implications on the realization rate. For each heat pump logged, Nexant recreated the TRM-expected reported savings using both $EFLH_H$ values. The results of this analysis are provided in Table 3-2, and suggest that Efficiency Maine's decision to reduce the $EFLH_H$ assumption improved the accuracy of their reported savings values for all projects completed after the adjustment.

Table 3-2: Impact of $EFLH_H$ Assumption on Ductless Heat Pump Realization Rates

Evaluation Method	TRM-Based kBTU Moved	Verified kBTU Moved	Realization Rate (%)
$EFLH_H$ = 2,976 hours	1,093,243	479,022	44%
$EFLH_H$ = 1,503 hours	665,615		73%

Further reductions to the overall ductless heat pump realization rate were attributed to a seasonality issue. The largest project in the sample, accounting for 51% of the reported kBTU moved, was a lodging facility that closes for business during the winter. The project included installation of new ductless heat pumps in 18 guest rooms. Nexant installed amp loggers on four units and found the $EFLH_H$ value to range from 690 hours to 1,238 hours. The realization rate of this project was only 7% because of the facility's winter closure. Removing this project from the sample increased the stratum's realization rate to 62.0%.

Efficiency Maine also made another major change to the ductless heat pump program since the conclusion of the evaluation period. Throughout the evaluation period, the ductless heat pump measure was used to describe ductless heat pumps installed to supplement existing heating systems or to replace window air-conditioning. The baseline heating fuel and air conditioning details were inputs available to the applicant, which were used to configure the baseline consumption. The 2016 TRM however described this measure as a ductless heat pump installed as a primary heating system in new-construction projects. The 2016 TRM calculated the baseline consumption assuming the facility would be heated with new ductless heat pumps that only meet minimum federal efficiency requirements; the savings then being only for the incremental efficiency over the minimum code. Calculating the savings in this fashion removes the implications of the fuel-switching aspect that was prevalent during Nexant's evaluation. However, with the savings being a function solely of the change in efficiency of the unit, $EFLH_H$ will play a larger role in future calculations than it did in previous iterations of the measure.

Because of the restructuring of this measure, the projects sampled as part of this evaluation can no longer be considered representative of projects that will participate in future program years. Based on the $EFLH_H$ analysis summarized in Table 3-2 Nexant stresses the importance of Efficiency Maine's confidence in their $EFLH_H$ assumptions moving forward, but cannot provide an updated value given the restructuring of the measure.

3.1.1.3 Prescriptive Lighting Findings

As expected, the stratum-wide realization rate of the prescriptive lighting program was the highest within the portfolio. Project-level realization rates within the stratum ranged from 2.7% to 366% with a major outlier at 1,762%. This outlier was the result of technical issues that Efficiency Maine experienced as they upgraded their online tracking portal from an older to a newer version. Because the reported savings associated with this project were minimal (reported: 7,737 kWh, verified: 136,333 kWh), it did not affect the overall realization rate of the stratum. Other recurring issues that affected the realization rates were poor correlations between observed and reported hours of use, often as a result of seasonal business closures, inaccurate LED wattage assumptions, and failure to include full lighting inventories for LPD-based savings calculations (as previously discussed in Section 3.1.1.1).

Annual Operating Hours

The TRM algorithm for prescriptive lighting measures includes an "HoursWk" term and a "Weeks" term. These terms represent the hours of use per week and the weeks of use per year respectively, and are to be supplied by the user in effRT. effRT multiplies the values together to arrive at an annual HOU. The 2015 TRM noted that if actual hours were unknown, deemed values were to be used. Table 3-3 presents a comparison of the TRM-deemed and observed HOU values determined by Nexant through data logging. More detailed results of the logger analysis are presented in Appendix A. The analysis included calculation of summer and winter coincidence factors, and the energy period factors of each logger installed.

Table 3-3: Deemed and Observed Lighting Hours of Use

Building Type	Logged Sites	Average Logged Hours of Use	TRM Deemed Hours of Use
Exterior	*	4,832	4,380
Garage/Repair	3	3,590	4,056
K-12 Schools	1	2,946	2,187
Lodging (Common)	2	1,617	3,064
Lodging (Guest)	1	3,912	3,064
Manufacturing	7	3,877	2,857
Office	5	6,793	3,100
Other	5	3,248	2,278
Restaurant	4	4,384	4,182
Retail	6	2,313	4,057
Warehouse	4	4,378	2,602

**Exterior spaces were not logged. Nexant used historical sunrise and sunset data recorded in Bangor and Portland, Maine, to create an 8,760 load shape of expected photocell operation. Nexant assumed the lights would come on one half-hour before dusk and stay on until one half-hour after dawn.*

The table shows a poor correlation between observed and deemed values for most building types logged; however, this is inconsequential because the reported savings for all 66 projects in the prescriptive lighting sample were calculated using customer-supplied HOU values.

Nexant's evaluation found that many of the sites operate seasonally; however, the applicants in these cases frequently input 52 as the "Weeks" term, suggesting applicants may have been confused about which value they should be using for this term, or how this value would be used by the database. Ongoing discussions with EMT on this topic led to a change in program rules whereby seasonal facilities are no longer allowed to participate in future program years.

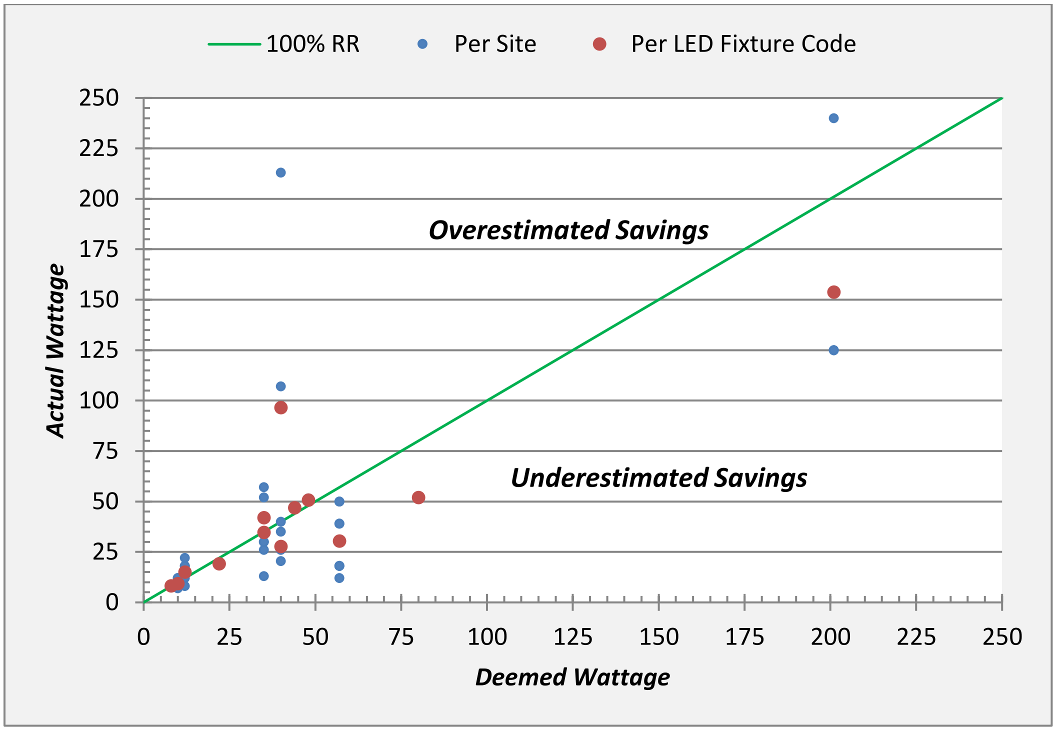
Inaccurate LED Wattage Assumptions

The prescriptive lighting program assigned assumed wattages to installed LEDs based on the lamp or fixture type. For example, all LED A-Lamps were assumed to be 10 watts. However, the description "A-Lamp" represents the shape of the bulb, and has no bearing on the wattage. "Osram Sylvania's 2015 Lamp and Ballast Catalog"[1] provides wattages of their full line of LED A-lamps, which range from 4 to 17 watts. Although 10 watts may be a good approximation, given the small range of available wattages in this instance, many other fixture types can see larger ranges of possible wattages. Since the period under evaluation, the program has refined the lighting bins to provide more narrow ranges of wattages to improve the accuracy of the deemed wattage and measure costs.

[1] "Osram Sylvania's 2015 Lamp and Ballast Catalog" is available at http://assets.sylvania.com/assets/onlinemedia/ihdp/Lamp-and-Ballast-Catalog/#?page=0.

Figure 3-1 shows a comparison of the verified wattages and deemed wattages of all LED fixtures included in the prescriptive lighting sample. Each blue dot represents one unique instance of each measure code; the red dots represent the average observation across each measure code.

Figure 3-1: Verified versus Deemed Wattages of LED Fixtures



In general, the graph shows good alignment between verified and deemed wattages for fixtures that carry low assumed wattages. However, at higher assumed wattages, the assumptions appear to be less accurate. Table 3-4 tabulates the results of all 13 LED measure codes encountered in the evaluation sample.

Table 3-4: Verified and Deemed Wattages of LED Fixtures

LED Measure Description	Sample Size	Deemed Wattage (W)	Average Verified Wattage (W)	Savings Result
LED 1x4 recessed fixture > 40W	2	48	51	understated
LED 2x2 recessed fixture < 50W	2	40	28	overstated
LED 2x4 recessed fixture < 50W	1	44	47	understated
LED A	5	10	9	no effect
LED D	4	12	15	understated
LED flood/spot < 100W	8	57	31	overstated
LED high/low bay fixture > 120W	4	201	154	overstated
LED linear ambient < 50W	3	35	42	understated
LED PAR 20	3	8	8	no effect
LED PAR 38	2	22	19	overstated
LED pole-mounted < 50W	4	40	97	understated
LED pole-mounted 50W–100W	1	80	52	overstated
LED wall pack	6	35	35	no effect

Note that of the four sample points in the “LED pole-mounted <50W” measure, two fixtures were found to be greater than the allowable 50 watts. The correct measure for these two projects would have been “LED pole-mounted 50W–100W”.

Waste Heat Factors

Finally, Nexant noted that while Efficiency Maine’s algorithm for calculating energy savings associated with lighting retrofits included a term designed to capture the interactive effects on the use of HVAC equipment, the factor was set to “1” for all measures A recent statewide study in a neighboring jurisdiction found that these interactive effects can influence the energy savings by up to 7%. Subsequent iterations of the TRM provided updated values.

3.1.1.4 Prescriptive Non-Lighting Findings

In general, most of the projects in the prescriptive non-lighting stratum hovered around a 100% realization rate, with one extreme outlier that carried a realization rate of 1,762%. This project entailed installation of eight high-efficiency evaporator fan motors in refrigerated warehouses. The 2015 TRM deemed motor sizes of 132 watts (approximately 1/10 HP) for the pre-retrofit motor, and 40 watts (approximately 1/30 HP) for the post-retrofit motor for this measure. The eight motors installed in this instance were 1.5 HP, which drew 1,119 watts each—a difference of 1,079 for each motor, all of which operated 8,760 hours annually. This project is not representative of other projects in the prescriptive non-lighting stratum, and as such, has been removed from all reported and verified savings calculations, precision calculations, and cost/benefit results.

3.1.2 Summer Demand Impacts

Efficiency Maine's TRM defines the summer peak window as 1:00 PM to 5:00 PM on non-holiday weekdays in June, July, and August consistent with ISO NE. The realization rates and gross demand impact estimates corresponding to this window are presented in Table 3-5.

Table 3-5: Gross Summer Demand Impact Estimates

Stratum	Ex-Ante Savings (kW)	Realization Rate (%)	Ex-Post Savings (kW)	Relative Precision at 80% Confidence (%)
Custom rebates	978	101.3%	991	-
Ductless heat pumps[1]	-115	42.0%	-48	-
Prescriptive lighting	12,201	75.7%	9,230	-
Prescriptive non-lighting	1,148	95.9%	1,101	-
Total	**14,213**	**79.3%**	**11,274**	**7.6%**

[1]The realization for the ductless heat pump stratum relies solely on the reported and verified kBTU moved and as such is the same for all evaluation parameters (energy, summer demand, and winter demand). This is explored in more detail in Section 3.2.2.

Anomalies and trends that affect the summer demand realization rates of the custom rebates and prescriptive non-lighting strata were previously discussed in detail in Sections 3.1.1.1 through 3.1.1.4.

3.1.2.1 Ductless Heat Pump Findings

The realization rate for the ductless heat pump stratum presented in Table 3-7 is not specific to demand impacts. As discussed in Section 2.2.3, this realization rate was created by comparing the TRM-assumed annual kBTU moved to the observed kBTU moved, and applied to energy and demand impacts alike. However, Nexant noted that Efficiency Maine's program used a summer coincidence factor of 37.2% for ductless heat pump measures, where the evaluation found the summer coincidence of the logged units to be only 20%. On-site interviews revealed that many ductless heat pumps operate in fan-only mode in the summer.

3.1.2.2 Prescriptive Lighting Findings

Efficiency Maine's TRM assigns summer coincidence factors to lighting measures in groups as shown in Table 4-6.

Table 3-6: Deemed Summer Coincidence Factors

Measure Type	CF_S
Interior fixtures	76.0%
Exterior fixtures	3.7%
Interior lighting controls	18.0%
LED exit signs	100.0%
Fixtures in refrigerated spaces	90.8%

For cost-effectiveness calculation purposes, Nexant created a stratum-wide summer coincidence factor from the 66 evaluated projects, as described in Section 2.2.2. The result of this analysis was a stratum-wide interior summer coincidence factor of 66.0% and an exterior factor of 0%. Note that this value was calculated as a function of the measure mix evaluated. If the measure mix of the program were to change significantly, this value would need to be re-examined.

Finally, Nexant noted that although Efficiency Maine's algorithm for calculating energy savings achieved by lighting retrofits included a term designed to capture the interactive effects on the use of HVAC equipment, the factor was set to "1" for all measures Recent statewide studies have shown that these interactive effects can influence the demand savings by up to 23%. Subsequent iterations of the TRM incorporated updated considerations for interactive effects.

3.1.3 Winter Demand Impacts

Efficiency Maine's TRM defines the winter peak window as 5:00 PM to 7:00 PM on non-holiday weekdays in December and January consistent with ISO NE. The realization rates and gross demand impact estimates corresponding to this window are presented in Table 3-7.

Table 3-7: Gross Winter Demand Impact Estimates

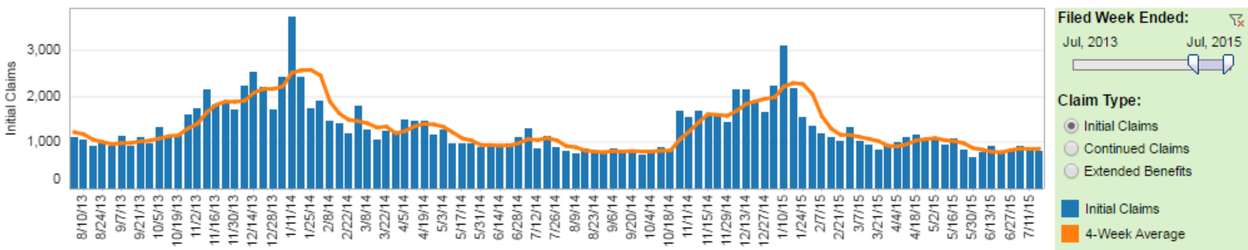
Stratum	Ex-Ante Savings (kW)	Realization Rate (%)	Ex-Post Savings (kW)	Relative Precision at 80% Confidence (%)
Custom rebates	1,334	81.2%	1,083	-
Ductless heat pumps[1]	290	42.0%	122	-
Prescriptive lighting	13,184	61.2%	8,073	-
Prescriptive non-lighting	1,150	73.7%	847	-
Total	**15,958**	**63.5%**	**10,126**	**10.9%**

[1]The realization for the ductless heat pump stratum relies solely on the reported and verified kBTU moved and as such is the same for all evaluation parameters (energy, summer demand, and winter demand). This is explored in more detail in Section 3.2.2.

Winter demand realization rates were significantly lower than summer demand realization rates. The precision surrounding these estimates was also lower than that of other parameters. These results were largely caused by seasonality as many businesses in the area close for the winter season.

To understand the extent of the seasonality issue, Nexant examined the precision of the winter demand impact estimates for the prescriptive lighting stratum only. Figure 3-2 shows the weekly unemployment filing statistics for the state of Maine over the duration of the evaluation period as reported by the Maine Department of Labor, Center for Workforce Research and Information[2]. In both program years, unemployment rates saw steep increases of up to 150% starting in October and lasting through March, which coincided with Efficiency Maine's winter peak window occurring December through January.

Figure 3-2: Statewide Number of Weekly Unemployment Claims



In keeping with the Department of Labor's research, Nexant's sample of 66 prescriptive lighting projects found that 22 sites observed seasonal operation coinciding with the winter peak window. Of the 22, 9 were closed completely for the season; the remaining 13 observed reduced hours of operation for the winter season. Table 3-8 shows the 22 facilities with observed seasonality, the claimed weeks of operation as found in the effRT application completed by the customer, and the Nexant calculated winter coincidence factor. For comparison, the standard winter coincidence factor for interior lighting fixtures as deemed by the 2015 TRM was 76%. Note that only three applicants used the "Weeks" term to describe the seasonality of their facility appropriately.

[2] Center for Workforce Research and Information is publicly available at http://www.maine.gov/labor/cwri/ui.html#tables.

Table 3-8: Seasonal Facilities Observed in the Prescriptive Lighting Sample

Enrollment	Building Type	Claimed Weeks of Operation	Observed Winter Coincidence
187797	Restaurant	26	0%
187802	Lodging (Common)	20	0%
187810	Lodging	52	0%
187812	Retail	52	0%
187866	Retail	52	0%
212081	Retail	52	16%
212085	Office	52	38%
245281	Manufacturing	52, 50	32%
246521	Garage/Repair	52	35%
250543	Office	52	8%
250719	Other	25	0%
252195	Office	52	0%
258831	Office	52	0%
265351	Retail	52	12%
266984	Manufacturing	52	14%
285299	Other	52	28%
285369	Lodging	52, 51	13%
286585	Garage/Repair	52	0%
287964	Garage/Repair	52	30%
293856	Garage/Repair	52	6%
249218	Lodging (Common)	52, 30	11%
282981	Retail	52	31%

In total, these 22 sites accounted for 70kW (or 24%) of the sample-wide reported winter demand savings (291 kW). The total verified savings of these sites was only 13kW, providing this subset of sampled sites with a realization rate of only 4%. Given the unemployment statistics presented by the Department of Labor, Nexant does not believe the sample to be biased towards these seasonal facilities. Efficiency Maine has already taken steps to alleviate this issue by not allowing seasonal businesses to participate in future programs.

3.1.3.1 Ductless Heat Pump Findings

Just as Efficiency Maine had reduced the EFLH assumptions associated with ductless heat pump measures, they also increased the winter coincidence factor. In December 2013, the winter coincidence factor was set at 55.7%. By September 2014, the winter coincidence recorded in the factor schedule was 68.0%. The evaluation found the winter coincidence of the logged units to be 63.0%. However, this observation has no bearing on the winter demand realization rate provided in Table 3-7 because the realization rate was created by comparing the

TRM-assumed annual kBTU moved to the observed kBTU moved, and then applied to energy and demand impacts alike.

3.1.3.2 Prescriptive Lighting Findings

Efficiency Maine's TRM assigns winter coincidence factors to lighting measures in groups as shown in Table 4-9.

Table 3-9: Deemed Winter Coincidence Factors

Measure Type	CF_W
Interior fixtures	63.0%
Exterior fixtures	70.2%
Interior lighting controls	12.0%
LED exit signs	100.0%
Fixtures in refrigerated spaces	84.7%

For cost-effectiveness calculation purposes, Nexant created a stratum-wide winter coincidence factor from the 66 prescriptive lighting calculator workbooks, as previously discussed in Section 2.2.2. The result of this analysis was a stratum-wide interior lighting winter coincidence factor of 66% and an exterior factor of 100%. Note that this value was calculated as a function of the measure mix evaluated. If the measure mix of the program were to change significantly, this value should be re-examined.

3.2 Net Savings Estimates

Net savings are the savings directly attributable to a program and account for the actions that the participant would have taken in absence of the program (freeridership) and the actions taken by a participant outside of the program incentive (spillover). Questions asked during the phone surveys and onsite visits were used to collect data needed to determine net savings for Efficiency Maine's BIP, including the basis of customer decisions to participate and to collect information on participant spillover. Net savings were derived by adjusting the realized gross energy-savings estimates to account for these freeridership and spillover estimates.

3.2.1 Participant Freeridership

As outlined in Section 2.2.6.1, the overall freeridership score was derived from two independently calculated elements, each of which is worth half of the total score: a stated intent/project change score and an influence score. Each element (stated intention and program influence) produced a range of freeridership values from 0 to 0.5 and were added together to produce a total freeridership score ranging from 0 (not a free-rider) to 1.0 (full free-rider). Table 3-10 presents the scores of each component by measure category.

Table 3-10: Participant Freeridership Estimate

Measure Category	Number of Respondents	Intention Score	Influence Score	Estimated Freeeridership (Intention Score + Influence)
Custom rebates	19	0.22	0.03	0.25
Ductless heat pumps	29	0.23	0.10	0.33
Prescriptive lighting	46	0.19	0.07	0.26
Prescriptive non-lighting	21	0.42	0.10	0.52

3.2.2 Participant Spillover

Participant spillover questions seek to understand if the customer invested in additional energy-efficiency measures for which they did not receive any Efficiency Maine incentives. The survey also asks for additional metrics that would enable Nexant to estimate attributable savings to these implemented measures. Participant spillover savings were included based on: 1) survey responses indicating the installation of additional measures, and 2) the ability to quantify those savings. Inability to quantify those savings leads to an understated spillover value. For example, spillover savings were not included from forty-two respondents who stated that they would have applied for a rebate if the program had not been suspended. Thus, Nexant was able to estimate spillover savings for 21 projects (Table 3-11).

Table 3-11: Participant Spillover Estimate

Project Count	Quantifiable Spillover Savings	Evaluated Program Population kWh	% Spillover
21	83,376 kWh	5,228,148 kWh	1.6%

3.2.3 Net-to-Gross Estimates

Using the values for freeridership and spillover presented in the sections above, Nexant calculated NTG values by measure category, as outlined in Table 3-12. Estimated precision is also presented.

Table 3-12: BIP Net-to-Gross Estimates

Measure Category	Number of Respondents	Estimated Freeridership	Estimated Participant Spillover	NTG Ratio	Margin of Error	Relative Precision
Custom rebates	19	0.25	0.02	0.77	±0.08	17.3%
Ductless heat pumps	29	0.33	0.02	0.69	±0.07	10.7%
Prescriptive lighting	46	0.26	0.02	0.76	±0.06	8.2%
Prescriptive non-lighting	21	0.52	0.02	0.49	±0.07	14.8%
BIP Program				0.72		6.0%

Nexant found the program-level NTG ratio to be 0.72 (72%) with ±6% precision at the 80% confidence level.

3.2.4 Net Energy Impacts

The net energy impacts are the product of the calculated gross energy savings and the net-to-gross ratios. The net energy impacts for the BIP are summarized in Table 3-13.

Table 3-13: BIP Net and Gross Energy Impacts

Stratum	Gross Energy Savings (kWh)	NTG Ratio	Net Energy Savings (kWh)
Custom rebates	6,739,399	0.77	5,189,337
Ductless heat pumps*	-35,819	0.69	-24,715
Prescriptive lighting	74,654,800	0.76	56,737,648
Prescriptive non-lighting	8,943,455	0.49	4,382,293
BIP Weighted Total	**90,301,835**	**0.72**	**65,017,321**

**DHP savings appear negative because they often pertain to measures in which gas heating equipment was removed and electric heating equipment was installed.*

3.3 Cost-Effectiveness Estimates

Nexant analyzed the cost-effectiveness of the BIP at the program and stratum-level based on the Total Resource Cost Test (TRC) and the Program Administrator Cost Test (PAC). The TRC test measures the costs of the program to society as a whole by including both the participant and program administrator costs. The PAC measures the costs of the program from the program administrator's point of view by only including those costs incurred by the program administrator. A TRC ratio of greater than one is considered cost-effective to society; a PAC ratio of greater than one is considered cost-effective to the program administrator.

3.3.1 Cost Effectiveness Inputs

The use of CBAT for cost-effectiveness testing required the following inputs, which were provided by Efficiency Maine for Nexant's use:

- Generation markup (8.00%)
- Discount rate (2.43%)

Other inputs that are tracked and stored in effRT for use by CBAT include:

- 2015 avoided energy costs
- 2015 avoided capacity costs
- Incentive amounts
- Measure life
- Measure incremental cost
- Measure energy period factors

The final input into the calculations, program delivery costs, were taken from Efficiency Maine's 2014 and 2015 annual reports.

As discussed in Section 2.4.2, Nexant created custom factor schedules for use by CBAT. Realization and NTG rates were calculated independently for each stratum; however, energy period factors and coincidence factors could only be updated for measures that were analyzed using 8,760-hour load shapes, which included the ductless heat pump and prescriptive lighting strata. The coincidence factors and energy period factors for the custom rebates and prescriptive non-lighting strata were left as-is when loaded into CBAT. The custom factors that Nexant used for cost-effectiveness calculations are summarized in Table 3-14 and Table 3-15. Note that the energy period factors in Table 4-30 were calculated as a function of the measure mix evaluated. If the measure mix of the program changes significantly, these schedules should be re-examined.

Table 3-14: Nexant-Derived Energy Period Factors (EPF)

Stratum	Winter Peak EPF	Winter Off EPF	Summer Peak EPF	Summer Off EPF
Ductless heat pumps	9.8%	75.5%	1.7%	13.0%
Prescriptive lighting	43.6%	23.8%	21.0%	11.6%

Table 3-15: Nexant-Derived Factor Schedules

Stratum	Winter CF	Summer CF	Free-Ridership	Spillover	Energy RR	Demand RR
Custom rebates	-	-	28.0%	2.0%	86.6%	87.9%
Ductless heat pumps	63.0%	20.0%	33.0%	2.0%	42.0%	42.0%
Prescriptive lighting	36.0% (Int.) 100% (Ext.)	66.0% (Int.) 0.0% (Ext.)	26.0%	2.0%	88.7%	83.4%
Prescriptive non-lighting	-	-	52.0%	2.0%	112.2%	81.1%

3.3.2 TRC Testing

The reported and verified TRC ratios for the two-year evaluation period, which Nexant derived as described in Section 2.3.2, are shown in Table 3-16. The reported values in the table were obtained through CBAT as the annual reports did not present cost-effectiveness findings in the same strata as Nexant used in the evaluation. See Appendix B for a breakdown of the cost-effectiveness by program year.

Table 3-16: Stratum-Level and Program-Level TRC Ratios

Stratum	Gross Ex-Ante TRC	Gross Ex-Post TRC	Net Ex-Ante TRC	Net Ex-Post TRC
Custom rebates	2.46	2.08	2.02	1.91
Ductless heat pumps	1.38	0.56	1.38	0.51
Prescriptive lighting	2.31	1.75	1.94	1.49
Prescriptive non-lighting	5.50	6.62	3.66	4.50
Total	**2.29**	**1.81**	**1.90**	**1.52**

Overall, BIP proved to be cost effective via the TRC test method. Three of the four strata passed, with only the ductless heat pump measure being deemed not cost effective. However, Nexant is confident that Efficiency Maine’s recent restructuring of this measure will correct issues surrounding the cost-effectiveness of the ductless heat pump measure.

Nexant suspected that the participant costs used in the calculation of these TRC ratios were slightly understated, and the resulting TRC slightly overstated. Because of this, Nexant launched a stratum-wide realization-rate analysis of the deemed-measure costs. Nexant pulled a sample of 61 enrollments, and compared the deemed-measure costs to the invoices uploaded for the project. The results of this analysis are presented in Table 3-17, ordered by each measure’s share of incentive dollars contributed to the program. Interestingly, although Nexant expected to find LED costs to be *overstated*, the opposite was actually true.

Table 3-17: Prescriptive Lighting Measure Cost Analysis

Measure	Deemed Incremental Cost	Total Reported Costs	Total Verified Costs	Realization Rate
L10, linear fluorescent fixture retrofits	$36	$763,782	$1,459,853	191%
S50, recessed LEDs	*Varied*	$5,613,850	$4,839,219	86%
S12, LED wall-packs	$370	$1,339,131	$2,391,485	179%
L40, high-intensity fluorescent fixtures	*Varied*	$1,282,850	$1,010,376	79%
L15, new fluorescent fixtures	$85	$1,492,102	$3,245,783	218%
X10, exit signs	$47	$78,819	$45,250	57%
L20, fluorescent fixtures with reflectors	$86	$348,912	$1,171,904	304%
S10, parking lot LEDs	*Varied*	$4,385,260	$6,136,672	140%
S40, screw-in LEDs	$38	$2,290,307	1,686,142	74%
S20, LED downlights	$75	$1,664,058	$1,561,133	94%
S60, high-bay LEDs	*Varied*	$8,505,757	$5,754,492	68%
S16, LED canopy	$350	$1,220,600	$1,043,422	85%
L70, occupancy sensors	$120	$323,001	$3,242,253	1,004%
S22, LED flood lights	*Varied*	$594,250	$435,288	73%
S80, linear LEDs	*Varied*	$153,800	$100,910	66%
S14, parking garage LEDs	$585	$758,745	$902,787	119%
L35, indirect fluorescent fixtures	$107	$284,389	$438,349	154%
L30, high-efficiency fluorescent fixtures	$92	$106,352	$177,088	167%
L60, high-bay occupancy sensors	$74	$286,158	$282,320	99%
L25, CFL fixtures	$72	$3,528	$5,598	159%
Total, weighted by incentive dollars				**113%**

Key observations from this analysis are summarized in Table 3-18.

Table 3-18: Prescriptive Lighting Deemed-Cost Observations

Measure Groups with Understated Costs	Measure Groups with Overstated Costs
• Exterior LEDs • LED exit signs	• Interior LEDs • Linear fluorescent fixtures • Compact fluorescent fixtures

The costs of linear fluorescent fixtures were found to be in alignment for measures that involved T8 fixture retrofits. However, the linear fluorescent measures also encompassed T5 retrofits, which were more expensive, and did not appear to be accounted for in the deemed cost.

Nexant recommends that Efficiency Maine conduct more research into deemed measure costs for all TRM measures to ensure the accuracy of cost-effectiveness testing in future program years.

3.3.3 PAC Testing

The reported and verified PAC ratios for the two-year evaluation period, which Nexant derived as described in Section 2.3.2, are presented in Table 3-19. The reported values in the table were obtained through CBAT as the annual reports do not present cost-effectiveness findings in the same strata as those that Nexant used in the evaluation. Again, the BIP proved to be cost effective via the PAC method. See Appendix B for a breakdown of the cost-effectiveness by program year.

Table 3-19: Stratum-Level and Program-Level PAC Ratio

Stratum	Gross Ex-Ante PAC	Gross Ex-Post PAC	Net Ex-Ante PAC	Net Ex-Post PAC
Custom rebates	7.81	6.01	4.96	4.33
Ductless heat pumps	2.51	1.31	2.51	1.06
Prescriptive lighting	4.60	3.25	3.33	2.47
Prescriptive non-lighting	8.91	10.17	4.94	5.18
Total	**4.59**	**3.53**	**3.34**	**2.58**

3.4 TRM Adjustments

One of the major findings of the 2015 evaluation was the prevalence of seasonal facilities participating in the program. Due to the high variance in energy and demand savings associated with seasonal businesses, Efficiency Maine has opted to exclude seasonal facilities from participating in future iterations of BIP. Table 3-20 provides calculated lighting HOU and coincidence assumptions of only the sampled sites that did not operate seasonally.

Table 3-20: Calculated Lighting Parameters for Non-Seasonal Business

Facility Type	Data Points	HOU	CF_S	CF_W
Exterior	6	4,808	0%	78%
Garage/Repair	1	3,351	36%	29%
K-12 School	3	2,899	15%	33%
Lodging (Common)	0	-	-	-
Lodging (Guest)	1	3,912	17%	29%
Manufacturing	5	4,141	68%	35%
Office	5	6,846	68%	70%
Other	6	4,092	54%	51%
Restaurant	6	4,515	87%	95%
Retail	8	3,076	80%	26%
Warehouse	5	4,658	75%	30%

Appendix A Light Logging Results

Nexant's logger analysis was completed at the enrollment level for each of the sites receiving loggers. Loggers were installed in interior and exterior fixtures. In addition, exterior fixtures controlled by photocells were analyzed using historical sunrise and sunset data to confirm operating hours and peak coincidence. The results presented below have been weighted at the enrollment and the stratum level as described in Figure A-1.

Figure A-1: Weighted Hours of Use and Coincidence Factor Calculation Methodology

Space-specific coincidence factors are calculated for each measure according the the customer's account of when the lights are operational in the space.

Customer-Supplied Schedule		
Measure	Weekday Lights On	Weekday Lights Off
Measure 1	9:00 AM	3:00 PM
Measure 2	9:00 AM	5:00 PM
Measure 3	4:00 PM	10:00 PM
Measure 4	9:00 AM	4:30 PM

Calculation of Summer Demand					
Hour:	1:00 PM	2:00 PM	3:00 PM	4:00 PM	CF_S
% of time on	1.0	1.0	0.0	0.0	50%
% of time on	1.0	1.0	1.0	1.0	100%
% of time on	0.0	0.0	0.0	1.0	25%
% of time on	1.0	1.0	1.0	0.5	88%

Each line item is pre-populated with the site-specific calculated coincidence factor. This coincidence factor is overriden with logger data where available.

(1 Logger Deployed)		
Measure	Savings (kWh)	CF
Measure 1	50	0.50
Measure 2	150	1.00
Measure 3	500	0.25
Measure 4	100	0.90

(2 Loggers Deployed)		
Measure	Savings (kWh)	CF
Measure 1	50	0.50
Measure 2	150	0.85
Measure 3	500	0.45
Measure 4	100	0.88

(No Loggers Deployed)		
Measure	Savings (kWh)	CF
Measure 1	50	0.50
Measure 2	150	1.00
Measure 3	500	0.25
Measure 4	100	0.88

A weighted coincidence factor is created for each enrollment as the sumproduct of the line item savings and its CF divided by the total enrollment savings.

Weighted CF: 0.49

Weighted CF: 0.58

Weighted CF: 0.48

The stratum-wide weighted coincidence factor is created as the sumproduct of each enrollment's savings and its CF divided by the total sample savings.

Stratum-Wide		
Enrollment	Savings (kWh)	CF
Enrollment 1	800	0.49
Enrollment 2	800	0.58
Enrollment 3	800	0.48
	Weighted CF:	0.52

These details are provided for informational purposes only and are not representative of the way the factors are used in the TRM as the TRM assigns these values per measure, and loggers span multiple measures within each enrollment.

Table A-1: Light Logging Results, Hours of Use and Coincidence Factors

Enrollment ID	Facility Type	Loggers Installed	Weighted HOU	Weighted CF_S	Weighted CF_W
14159	Other	4	3,315	0.71	0.39
101195	Exterior	1	4,658	0.00	1.00
102159	Retail	2	2,905	0.96	0.04
187796	Retail	1	3,641	0.96	0.04
187802	Lodging (Common)	2	1,302	0.50	0.00
187855	Other	3	1,502	0.00	0.85
212081	Retail	3	1,507	0.44	0.16
212085	Office	6	2,244	0.73	0.38
212098	Manufacturing	2	5,053	0.58	0.59
222977	Exterior	1	4,934	0.00	0.58
223113	Restaurant	2	4,812	1.00	1.00
244072	Lodging (Guest)	4	3,912	0.17	0.29
244427	Retail	2	2,198	0.67	0.03
245205	Restaurant	3	4,276	0.32	1.00
245281	Manufacturing	3	2,638	0.81	0.32
245779	K-12 School	3	2,946	0.15	0.32
246156	Warehouse	2	2,808	0.02	0.30
246521	Garage/Repair	1	2,908	0.96	0.35
248969	Manufacturing	2	3,062	0.95	0.47
249218	Lodging (Common)	1	2,481	0.41	0.11
250732	Office	3	7,936	0.90	0.85
252697	Office	2	6,710	0.88	0.54
265351	Retail	3	2,554	0.90	0.12
266984	Manufacturing	2	2,142	0.86	0.14
281846	Warehouse	5	4,013	0.57	0.51
282460	Warehouse	3	2,858	0.85	0.12
282981	Retail	4	2,155	0.56	0.31
283768	Garage/Repair	3	3,351	0.36	0.29
283894	Office	3	4,535	0.16	0.40
283926	Manufacturing	3	2,185	0.46	0.12
285279	Manufacturing	3	2,123	0.67	0.11
285299	Other	1	1,570	0.71	0.28
287132	Manufacturing	3	6,367	0.57	0.55
287858	Other	1	4,480	0.10	0.89
287964	Garage/Repair	3	4,237	0.92	0.30
288310	Warehouse	2	7,036	0.79	0.46

Appendix B Yearly Cost Effectiveness Results

Table B-1: 2014 TRC Results

Stratum	Gross Ex-Ante TRC	Gross Ex-Post TRC	Net Ex-Ante TRC	Net Ex-Post TRC
Custom rebates	2.20	1.97	1.85	1.70
Ductless heat pumps	2.95	2.00	2.95	1.70
Prescriptive lighting	3.61	3.65	3.11	3.15
Prescriptive non-lighting	6.33	8.12	4.14	4.86
Total	**3.42**	**3.48**	**2.92**	**2.94**

Table B-2: 2015 TRC Results

Stratum	Gross Ex-Ante TRC	Gross Ex-Post TRC	Net Ex-Ante TRC	Net Ex-Post TRC
Custom rebates	3.25	2.54	2.36	2.20
Ductless heat pumps	1.31	0.45	1.31	0.41
Prescriptive lighting	2.11	1.37	1.75	1.17
Prescriptive non-lighting	5.67	6.51	3.66	4.50
Total	**2.11**	**1.46**	**1.90**	**1.52**

Table B-3: 2014 PACT Results

Stratum	Gross Ex-Ante PACT	Gross Ex-Post PACT	Net Ex-Ante PACT	Net Ex-Post PACT
Custom rebates	8.47	6.82	5.53	4.82
Ductless heat pumps	3.98	2.95	3.98	2.34
Prescriptive lighting	8.76	7.36	6.34	5.60
Prescriptive non-lighting	10.19	12.02	5.62	6.13
Total	**8.42**	**7.38**	**6.00**	**5.41**

Table B-4: 2015 PACT Results

Stratum	Gross Ex-Ante PACT	Gross Ex-Post PACT	Net Ex-Ante PACT	Net Ex-Post PACT
Custom rebates	7.89	5.70	4.84	4.22
Ductless heat pumps	2.35	1.07	2.35	0.88
Prescriptive lighting	3.98	2.49	2.88	1.89
Prescriptive non-lighting	9.29	10.29	5.17	5.19
Total	**3.96**	**2.74**	**2.91**	**2.00**

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