ONTARIO GAS DSM EVALUATION CONTRACTOR

2016 Natural Gas Demand Side Management Custom Savings Verification

Ontario Energy Board

Date: July 31, 2018

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GLOSSARY OF TERMS AND KEY CONCEPTS

Adjustment factor	The adjustment factors are ratios of savings that allow evaluation findings from a sample of projects to be applied to and "adjust" the population of program savings. Realization rates, and ratios are other common terms.
Baseline, base case	Energy use / equipment in place if the program measure had not been done
Building envelope	Exterior surfaces (e.g., walls, windows, roof, and floor) of a building that separate the conditioned space from the outdoors.
Capacity expansion (CE)	Measure that allows customer to increase production/productivity
CCM	Cumulative Cubic meters (cumulative m^3)
Code	Measure required by regulations for safety, environmental, or other reasons
C&I	Commercial and Industrial
Custom Program Savings Verification (CPSV)	Activities related to the collection, analysis, and reporting of data for purposes of measuring gross custom program impacts.
Customer - Enbridge	Unique customers can be identified based on the Con_acc_num and the contact information provided by Enbridge. A customer may have multiple site addresses, decision makers, Con_acc_nums, and utilities. Customers can only be identified for records for which we received contact information (ie records associated with con_acc_num that have measures in the sample or backup sample).
Customer - Union	Unique customers can be identified based on the AIMS ID and the contact information provided by Union. A customer may have multiple site addresses, decision makers, AIMS IDs, and utilities. Customers can only be identified for records for which we received contact information (ie records associated with AIMS ID that have measures in the sample or backup sample).
Demand side management (DSM)	Modification of perceived customer demand for a product through various methods such as financial incentives, education, and other programs
Early replacement (ER)	Measure that replaces a piece of equipment that is not past EUL and in good operating condition
Domain	Grouping of like projects. A domain may be defined as projects within a specific sector or a category of measure types, end uses or other.
Dual Baseline	Savings calculation approach which addresses or combines the savings associated with early replacement and the savings after the early replacement period.
Early replacement Period (ER Period)	Years that the existing equipment would have continued to be in use. This is the same as RUL.
Energy Advisors	Energy Advisors are utility and/or program staff who provide information to customers about energy saving opportunities and program participation, this term includes, but is not limited to, Enbridge's Energy Solutions Consultants and Union's Account Managers
Estimated useful life (EUL)	Typically, the median number of years that the measure will remain in service
Ex ante	Program claimed or reported inputs, assumptions, savings, etc.
Ex post	Program inputs, assumptions, savings, etc. which are verified after the claimed savings are finalized. Does not include assessment of program influence. Synonym for verified gross savings.
Gross savings	Gross savings are changes in energy consumption and/or demand directly caused by program-related actions by participants regardless of reasons for participation (savings relative to baseline, defined above)
In situ	Existing measure, conditions, and settings

Incentive	An incentive is a transfer payment from the utility to participants of a DSM program. Incentives can be paid to customers, vendors or other parties as part of a DSM program.
Incremental cost	The difference in purchase price (and any differences in related installation, implementation costs), at the time of purchase, between the efficient measure and the base case measure. In some early retirements and retrofits, the full cost of the efficient technology is the incremental cost.
Industry standard practice (ISP)	Common measure implemented within the industry
Input assumptions	Assumptions such as operating characteristics and associated units of resource savings for DSM technologies and measures
Lifetime cumulative savings	Total natural gas savings (CCM) over the life of a DSM measure. Can be claimed, gross, or net. Sometimes referred to as just "cumulative" or "lifetime."
Maintenance (Maint.)	Repair or maintain, restore to prior efficiency
Measure – Enbridge	Measures are identified in the tracking data as a unique combination of project code, project sub code, and ESM project ID. Multiple measures may belong to the same project.
Measure – Union	Measure refers to a project # in the tracking data. When referring to Union programs, measure and project are used interchangeably as there is one level provided in the tracking data.
Measurement and Verification (M&V)	Verification of savings using methods not including attribution/free-ridership assessment.
MF	Multifamily (multi-residential).
New construction (NC)	New buildings or spaces
Non-early replacement period (non-ER period)	Years after the ER period up to the EUL
Normal replacement (NR)	Measure that replaces a piece of equipment that has reached or is past its EUL and in good operating condition
Persistence	The extent to which a DSM measure remains installed, and performing as originally predicted, in relation to its EUL
Program evaluation	Activities related to the collection, analysis, and reporting of data for purposes of measuring program impacts from past, existing, or potential program impacts
Project - Enbridge	Projects are identified in the tracking data based on the project code. A project may have multiple measures as indicated by sub-codes in the current data tracking system.
Project – Union	Projects are identified in the tracking data based on project # or project ID. When referring to Union programs, measure and project may be used interchangeably as there is one level provided in the tracking data.
Remaining useful life (RUL)	The number of years that the existing equipment would have remained in service and in good operating condition. This is the same as ER Period.
Realization Rate	A combination of adjustment factors, which represents ratios between two savings values. For example, the final realization rate is the ratio between evaluated savings and program claimed savings.
Replace on burnout (ROB)	Measure that replaces a failed or failing piece of equipment
Retrofit add-on (REA)	Measure reduces energy use through modification of an existing piece of equipment
Site	Sites are identified based on unique site addresses provided by Union and Enbridge through the contact information data request. A site may have multiple units of analysis, measures, and projects. Sites can be identified by the evaluation only for records for which we receive contact information – ie records associated with con_acc_num (EGD) or AIMS ID (Union) that have projects in the sample or backup sample.

System optimization (OPT)	Improve system or system settings to exceed prior efficiency
TSER	Telephone Supported Engineering Review
Unit of Analysis – Enbridge	The level at which the data are analyzed, which in 2016 is a "measure" or sub-project level for Enbridge
Union Influence Factor	Factor applied by Union to a small number of projects in 2016. The factor reduced ex ante (claimed) savings to account for anticipated partial free ridership. In this report, the savings reported have the factor removed.
Unit of Analysis - Union	The level at which the data are analyzed, which in 2016 is a project for Union. A project is equivalent to a measure for Union as the database did not have a sub-project level.
Vendors	Program trade allies, business partners, contractors and suppliers who work with program participants to implement energy saving measures

1 EXECUTIVE SUMMARY

This report has been prepared for the Ontario Energy Board (OEB). The study includes results from Custom Program Savings Verification (CPSV) of Enbridge Gas Distribution Inc.'s (Enbridge) and Union Gas Limited's (Union) natural gas demand-side management (DSM) programs delivered in 2016.

The study provides verified savings ratios and verified gross savings totals. Projects included are shown in Table 1. In this study of 2016 programs, custom Market-Rate Multi-Residential (Multi-family) projects are included, while custom Low Income Multi-Residential projects are not included.

Table 1: CPSV by program

Program		2016 CPSV
Union Custom	Large Volume	✓
	Commercial & Industrial*	✓
Enbridge Custom	Commercial*	✓
	Industrial	✓

*Custom Market-Rate Multi-Residential (Multi-family) projects are included as a part of this program.

1.1 Background

Enbridge and Union deliver energy efficiency programs under the Demand Side Management Framework for Natural Gas Distributors (2015-2020)[1] developed by the OEB.

In April 2016, the OEB hired an Evaluation Contractor (EC) team led by DNV GL to develop an overall evaluation, measurement, and verification (EM&V) plan. The objectives of the plan were to:

- Assess portfolio impacts to determine annual savings results, shareholder incentive and lost revenue amounts, and future year targets.
- Assess the effectiveness of energy efficiency programs on their participants and/or market, including results on various scorecard items.
- Identify ways in which programs can be changed or refined to improve their performance.

Under the plan, the DNV GL team conducted a verification of gross savings for custom projects implemented as part of the 2016 program year. Verification entails reviewing a statistical sample of measures installed through the programs. For this sample of measures, the DNV GL team reviewed savings calculations, ensured reasonable approaches were used, and conducted phone and/or onsite verification of implemented measures to verify the accuracy of assumptions and inputs. This report is a result of that study.

An evaluation advisory committee (EAC) provides input and advice to the OEB on the evaluation and audit of DSM results. The EAC consists of representatives from Union and Enbridge as well as representatives from non-utility stakeholders, independent experts, staff from the Independent Electricity System Operator (IESO), and observers from the Environmental Commissioner of Ontario and the Ministry of Energy. The DNV GL team worked closely with the EAC throughout this study and received comments, advice, and input on methodology and results. We thank them for their involvement.

[1] EB-2014-0134

1.2 Methodology summary

The results presented in this report are based on data collection from the following four primary sources, supplemented with secondary source information:

- Union and Enbridge tracking databases
- Union and Enbridge project documentation
- In-Depth Interviews with a sample of participating customers and vendors
- On-site visit to a sample of participating customer sites

The data collection with a sample of participating customers included site visits and telephone interviews supporting a detailed measurement and verification (M&V) analysis. Table 2 shows the targeted and completed data collection activities.

Table 2. Data collection activities*

Target Group	Activity	Targeted Measures	Completed Measures
Enbridge			
Participating Customers	M&V Site Visit (On-site)	48	26
	TSER Interview		26
Union			
Participating Customers	M&V Site Visit (On-site)	62	54
	TSER Interview		16
Overall			
Participating Customers	M&V Site Visit (On-site)	110	80
	TSER Interview		42

*This table reports the number of measures targeted and completed as measures were used to design the sample before customers and sites had been identified.

At a high level, the gross savings verification (CPSV) study employed the following methodology:

- **Review program data and documentation.** The evaluation started with a review of the program tracking data, which formed the basis of the sample, and an initial review of the program documentation. Once the sample was selected, additional documentation was provided by the programs to describe the energy efficiency measures and support the tracking savings estimates, also called the ex ante estimates.
- **Design and select the sample.** The tracking data was used to design and select a sample. Full documentation and contact information was requested for all sites within the sample.
- **Collect data.** Data was collected to verify the ex ante energy savings.
- **Analyze the results.** The collected data was used to verify the gross savings at each site.
- **Report the results.** The final step was to report the results.

1.3 Results

The outcome of the exercise produced verified gross savings for the 2016 programs studied. Table 3 provides the results of the evaluation for Union Custom programs and Table 4 provides the results of the evaluation for Enbridge Custom programs.

Table 3: Union custom programs verified gross savings results*

Program	Claimed Savings	Effective Gross Realization Rate	Verified Gross Savings
Commercial and Industrial Custom	1,538,593,562	100.70%	1,549,389,975
Custom Large Volume	844,735,540	100.98%	853,013,948

*Ratios in this table have been rounded and are the effective overall ratios, calculated by first applying the ratios by segment and then dividing the total verified savings by the total claimed savings. Claimed and verified savings each have the "Union influence factor" removed.

Table 4: Enbridge custom programs verified gross savings results*

Program	Claimed Savings	Effective Gross Realization Rate	Verified Gross Savings
Custom C&I and Market Rate Multi-residential	825,138,165	109.02%	899,531,473

*Ratios in this table have been rounded and are the effective overall ratios, calculated by first applying the ratios by segment and then dividing the total verified savings by the total claimed savings.

1.3.1 Findings

Key findings from the study include:

- Both utilities generally produce solid ex ante engineering estimates of savings that are not systematically biased. Much of the variation in gross realization rates is driven by changes in operating conditions that are often difficult to anticipate in ex ante savings estimation
- Both utilities could provide better supporting documentation of assumptions and inputs in their savings estimates and each could benefit from investing in a modern program tracking database with document storage capabilities

1.3.2 Recommendations

Recommendations from the evaluation are summarized in to . In the tables the primary outcomes of the recommendation are classified into four categories: reduce costs, increase savings, increase (or maintain) customer satisfaction and decrease risk (multiple types of risk are in this category including risk of adjusted savings, risk to budgets or project schedules, and others). For a more thorough explanation of recommendations and the findings on which they are based, see section 6.

Table 5: Energy savings and program performance recommendations

#	Energy Savings and Program Performance		Applies to			Primary Beneficial Outcome			
	Finding	Recommendation	Union	Enbridge	Evaluation	Reduce Costs	Increase Savings	Increase Customer Satisfaction	Decrease Risk
1	Both utilities exhibit a strong commitment to accurate energy savings estimate	The utilities should continue in their commitment to accuracy.	✓	✓				✓	✓
2	The CPSV effort found realization rates near 100% and identified adjustments for most projects.	Continue performing custom savings verification on a regular basis.			✓				✓
3	Relative precision targets were met or surpassed for all programs	Use error ratio assumptions from the results provided in this report in future evaluation years, but with more conservative bounding than performed this year.			✓	✓			✓
4	Some measures have difficult-to-define baseline technologies.	Establish a policy to define rules around energy savings calculation for fuel switching and district heating/cooling measures.	✓	✓	✓				✓
5	Review of documentation for gross evaluation showed that several projects were high free rider risks.	Review projects with large incentives for free ridership risk. Develop clear program rules that allow the utility to reject free rider projects.	✓	✓			✓		✓
6	Influence adjustments were made to projects that adjusted the gross savings for "net" or program influence reasons.	Increase transparency of "influence adjustments" and do not include in gross savings	✓				✓	✓	✓
7	There is not a clear policy to determine "standard" baselines.	Establish a clear policy to determine and define "standard" baselines	✓	✓	✓	✓			✓

#	Energy Savings and Program Performance		Applies to			Primary Beneficial Outcome			
	Finding	Recommendation	Union	Enbridge	Evaluation	Reduce Costs	Increase Savings	Increase Customer Satisfaction	Decrease Risk
8	Some measures in each utility program are routine maintenance or periodic repairs that are considered standard care in other jurisdictions.	Establish a clear policy regarding eligibility of maintenance and repair measures for the programs.	✓	✓	✓	✓			✓
9	The programs did not consistently account for interactivity among measures.	Add an interactivity check to the programs' internal QC process for savings estimates.	✓	✓	✓	✓			✓

Table 6: Verification process recommendations

#	Verification Process		Applies to			Primary Outcome			
	Finding	Recommendation	Union	Enbridge	Evaluation	Reduce Costs	Increase Savings	Increase Customer Satisfaction	Decrease Risk
10	DNV GL was unable to obtain access to all the equipment at all the sites selected for verification.	Modify contracts to require participants to agree to comply with EM&V as part of the requirements for participation in the program.	✓	✓		✓			✓
11	Future evaluations should consider large HVAC to be high rigour rather than standard rigour.	Consider large HVAC measures for higher rigour verification.			✓				✓

Table 7: Documentation and Support recommendations

#	Documentation and Support		Applies to			Primary Outcome			
	Finding	Recommendation	Union	Enbridge	Evaluation	Reduce Costs	Increase Savings	Increase Customer Satisfaction	Decrease Risk
12	Incremental improvement in project documentation by both utilities was observed in the 2016 CPSV. Project documentation for some projects lacked sufficient details to allow evaluators to reproduce the calculations made by program staff or third-party vendors.	Take steps to improve documentation: • Implement an electronic tracking system that archives all materials • Include explicit sources for all inputs and assumptions in the project documentation. • Store background studies and information sources with the project files and make them available to evaluators. • Provide evaluators full access to customer data. • Provide pre- and post-installation photos, where available. • Document and provide internal M&V documents where available. • Institute a checklist as part of project closeout to ensure all relevant project documentation is assembled as ready for verification	✓	✓			✓		✓

#	Documentation and Support		Applies to			Primary Outcome			
#	Finding	Recommendation	Union	Enbridge	Evaluation	Reduce Costs	Increase Savings	Increase Customer Satisfaction	Decrease Risk
13	Explanations of complex projects were not consistently clear making it hard to understand what process is actually producing energy savings.	Improve clarity and details of documentation explaining the source of energy savings for complex projects.	✓	✓					✓
14	Ex ante savings estimates based on annual energy consumption for industrial sites did not always include sufficient information documenting production.	Include site production totals in relevant years in the savings estimates based on annual energy consumption for industrial sites	✓	✓					✓
15	Enbridge Boilers use a 73% assumed thermal efficiency for in situ boilers that have been in place for more than 10 years.	Estimate boiler degradation from name plate efficiency to determine the baseline boiler efficiency rather than a flat number	✓	✓					✓
16	Pipe insulation is a significant source of savings for the Union Gas programs. Documentation for the source of factors used in calculations and of in situ conditions was not consistently provided.	Document baseline conditions of pipe insulation (and other measures) using photos and text descriptions to provide context. Explicitly tie the documentation of baseline condition to the heat loss rate used for the savings calculation.	✓	✓					✓

#	Documentation and Support		Applies to			Primary Outcome			
#	Finding	Recommendation	Union	Enbridge	Evaluation	Reduce Costs	Increase Savings	Increase Customer Satisfaction	Decrease Risk
17	Enbridge documentation did not always include a prose explanation and supporting documentation for baseline types (ROB, ER) and remaining useful life (RUL).	Always complete the “Base Case Overview” in the form with a prose description of the base case. The description should reference included emails and photos to document in situ conditions and features that are carried over into the baseline system.		✓					✓
18	The utilities should use longer duration data in ex ante savings estimates when possible.	Use longer duration data in ex ante savings estimates. When time periods less than a year are used, documentation should be provided to indicate why the period used is applicable to a full year and why a full year was not able to be used.	✓	✓		✓			✓
19	In situ boiler name plate information, age and operating condition are all helpful for determinizing the designed performance and reasonable range of actual efficiency for the system as well as providing context to better determine remaining useful life (RUL)	Document in situ boiler name plate information, age and operating condition for all projects where boiler efficiency affects savings	✓	✓					✓

#	Documentation and Support		Applies to			Primary Outcome			
	Finding	Recommendation	Union	Enbridge	Evaluation	Reduce Costs	Increase Savings	Increase Customer Satisfaction	Decrease Risk
20	Items that may be obvious to the ex ante team can be non-obvious to an outside party.	Review ex ante documentation from an outside perspective to help identify gaps	✓	✓					✓
21	At large sites with multiple spaces containing similar equipment, ex ante documentation did not always identify which space or piece of equipment was affected by the project.	Include additional descriptions of spaces and equipment affected to differentiate among similar spaces and equipment at the site.	✓	✓					✓
22	Invoices were not always included with documentation, and sources for incremental costs were not always clear.	Ensure that incremental costs are supported by invoices or other documentation, especially for add-on and optimization measures where the total cost and incremental cost are likely to be the same.	✓	✓				✓	✓
23	Larger projects appeared to fall under the same documentation standards as smaller projects.	Increase the amount of documentation and source material for projects that have greater energy savings.	✓	✓					✓

#	Documentation and Support		Applies to			Primary Outcome			
	Finding	Recommendation	Union	Enbridge	Evaluation	Reduce Costs	Increase Savings	Increase Customer Satisfaction	Decrease Risk
24	Union's custom project summary workbook is a good approach to documentation. The workbook is not used in a consistent manner across all projects.	Consider providing more training or adding quality control steps to ensure the summary workbook front page is completed and stored in a consistent manner. Identify a common approach for common measures and, if necessary, document deviations and the reasons for the deviations in a clearly labelled field on the summary sheet.	✓			✓			✓
25	Enbridge Etools does not sufficiently document sources of inputs and assumptions.	Use a consistent summary workbook.		✓		✓			✓

Table 8: Data management recommendations

#	Data Management		Applies to			Primary Outcome			
	Finding	Recommendation	Union	Enbridge	Evaluation	Reduce Costs	Increase Savings	Increase Customer Satisfaction	Decrease Risk
26 A	Neither Union nor Enbridge currently track participating customer or participating vendor contact information in their program tracking database. Providing the information to the evaluation puts significant burden on utility staff. In 2016, the data provided by utility staff was much more consistent and clear relative to 2015.	Track contacts associated with projects in the program tracking database.	✓	✓		✓		✓	✓
26 B		Strongly consider investing in relational program tracking databases.	✓	✓		✓	✓	✓	✓
26 C		Continue to use improved structure for data integrity in the evaluator request for contact information for the 2017 savings verification and evaluation.			✓	✓		✓	
27	The extracts from the utility program tracking database do not include dates for key project milestones.	Track and provide to evaluators dates for key milestones in the project.	✓	✓		✓			✓
29	EUL and cumulative gross savings were not provided in a consistent manner in the Enbridge program tracking database extract	Include separate fields in the program tracking database for all components of gross and net cumulative and first year savings.	✓	✓			✓		✓

2 INTRODUCTION

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Table 9: CPSV by program

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[2] EB-2014-0134

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- **Design and select the sample.** The tracking data was used to design and select a sample. Full documentation and contact information was requested for all sites within the sample.
- **Collect data.** Data was collected to verify the ex ante energy savings.
- **Analyze the results.** The collected data was used to verify the gross savings at each site.
- **Report the results.** The final step was to report the results.

Key features of the methodology include:

- The **sample design** employed a stratified random sample that targeted 10% relative precision with 90% confidence at the program level. Details of the sampling methods are presented in Appendix C. Final sample achievements are provided in Appendix A.

- **Ratio estimation** was used to expand sample results to the population. The evaluation collected data on all sampled or backup projects that a customer contact could speak to rather than only the first selected. In our calculation of sampling error (+/-, confidence intervals, relative precision and error ratios), we used two-tailed 90-percent confidence limits and clusters defined by customers to appropriately estimate error when multiple units are collected from a single source.[3] The approach used is described in Appendix E.
- The **gross savings verification** used a combination of on-site data collection and interviews to collect primary data. Calculation of lifetime gross savings used a dual baseline approach to more accurately estimate savings for early replacement measures. Detailed site reports for each of the sites visited or called were prepared by the DNV GL team and reviewed by the EAC.

2.1.1 Understanding Statistical Error

Statistical error is reported for all of the ratio results in this report. The studies were designed with sample designs targeting 10% relative precision with 90% confidence (90/10) based on the best available assumptions at the start of the evaluation. Table 11 describes each of the statistics provided in this report.

Table 11: Relevant statistics.

Term	Definition
Ratio/Adjustment factor	A point estimate of the evaluation findings expressed as a percent.
+/- or Absolute Precision	If the evaluation were repeated several times, selecting samples from the same population, 90%[4] of the time the ratio would be within this range of the ratio
Confidence interval	The upper bound is defined by the ratio plus the absolute precision. the lower bound is defined by the ratio minus the absolute precision.
Relative Precision	The relative precision is calculated as the absolute precision divided by the ratio itself. By convention, relative precisions are the statistic that are targeted in sampling (i.e., 90/10 is a relative precision metric)
Error Ratio	The error ratio is an approximation of the coefficient of variation (cv) that is used in sample design. It is calculated as a function of relative precision.
Finite population correction (FPC)	FPC is a factor that reduces the measured error of samples drawn from small populations (less than 300). FPC applies when the ratio is applied to the same population from which the sample was drawn. Statistics reported in the body of this report all employ the FPC factor.

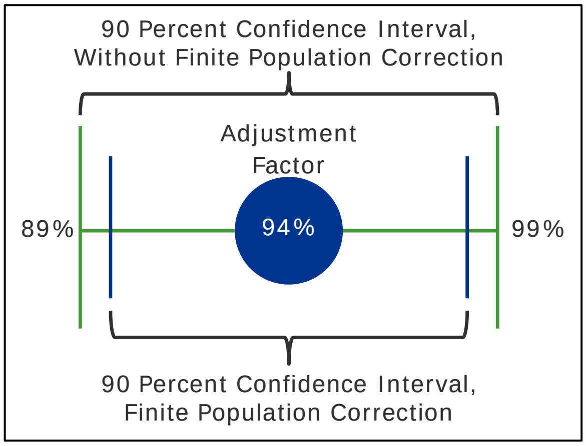
Figure 1 shows an example of:

- the adjustment factor (ratio) as a blue point

[3] Where a single site had two contacts, the site was used as the cluster to ensure conservative (higher) error estimates.
[4] 90% is the confidence limit that we are using.

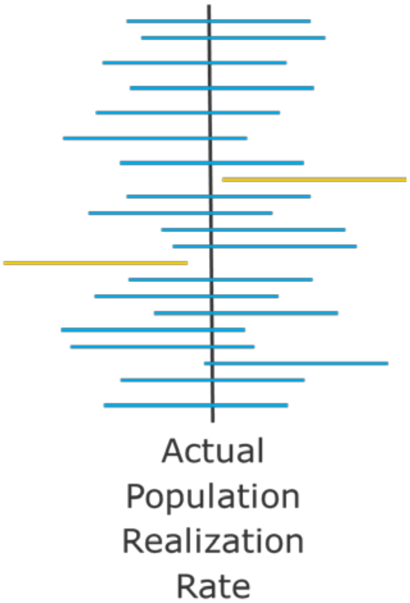
- the 90% confidence interval *with finite population correction* (blue)
- the 90% confidence interval *without finite population correction* (green)

Figure 1: Ratio diagram example



The plus/minus (±) error (%) indicated at the 90% confidence interval is the absolute difference between the estimated percentage and the upper or lower confidence bound. For example, in Figure 1, the ratio is 94% and the non-FPC 90% confidence interval is ± 5 percentage points (i.e., 94% ± 5%).[5] Another way of saying this is that there is a 90% probability that the actual ratio for the next year's program lies between 89 and 99%. Figure 2 demonstrates this concept by showing twenty hypothetical confidence intervals calculated from twenty different samples of the same population. Eighteen out of twenty (90%) include the true population ratio (overlap the black line representing the true ratio).

Figure 2. Ninety Percent Confidence Interval



[5] The critical value for calculating the confidence interval ± for each adjustment factor is determined using Student's t-distribution and n-1 for the degrees of freedom, where n is the sample size. For 2-tailed estimates (ratios that could be above or below 100%) the appropriate t-stat used to calculate precision from the standard error is close to 1.645.

Note: Each horizontal line represents a confidence interval, while the black vertical line is the actual population realization rate. Yellow confidence intervals do not include the actual ratio.

The relative precision of the ratio is calculated as 5%/94% =5.3%.

For low ratios, relative precisions may be quite high, even when the confidence interval around the ratio is quite narrow. Consider a ratio of 5% with the same 5% absolute precision as in the above example. While the absolute precisions are the same, the latter ratio (5%) has a relative precision of 5%/5% =100%. In absolute terms, we still are 90% confident the ratio is below 10%, despite the very high (100%) relative precision.

We reported the relative precision in all cases at the 90% confidence level. That is, whether the relative precision is large or small, we have the same 90% confidence that the range defined by the point estimate +/- the absolute error captures the true unknown value. The “midpoint” estimate (the ratio) is the best (statistically most likely) estimate, while the confidence interval is calculated as an interval around that point. Thus, in all cases, we reported the best point estimate, with a symmetric 90% confidence interval (using the t-score for a 2-tailed 90% confidence interval).

3 UNION COMMERCIAL, INDUSTRIAL, AND MULTI-FAMILY PROGRAMS

Custom programs for commercial and industrial (C&I) customers have been designed to encourage commercial and industrial customers to reduce their energy consumption by providing customer-specific energy efficiency and conservation solutions. The custom programs provide financial incentives, technical expertise, and guidance with respect to energy-related decision making and business justification, including helping customers to prioritize energy efficiency projects against their own internal competing factors and demonstrating the competitive advantage customers can gain through efficiency upgrades. These custom programs differ from the prescriptive programs as they provide tailored services and varying financial incentives based on overall natural gas savings realized by the customer to address customer-specific needs. Custom program performance is measured in cumulative gas savings (CCM), also known as total lifetime savings.

Union Custom C&I program focuses on advancing customer energy efficiency and productivity by providing a mix of custom incentives, education, and awareness to C&I customers across all segments. The objective of the Custom program is to generate long-term and cost-effective energy savings for Union's customers.

The Union Custom program covers opportunities where energy savings are linked to unique building specifications, design concepts, processes and new technologies that are outside the scope of prescriptive and quasi-prescriptive measures. The program and incentives are targeted directly to the end user, while trade allies involved in the design, engineering and consulting communities assist to expand the message of energy efficiency.

A subset of the projects in these programs is part of the multi-family or multi-residential segment. In this report, we refer to these projects as Market-Rate Multi-family (MR MF) in order to distinguish them from the low income multi-family (LI MF).[6]

All projects implemented as part of these programs and claimed in 2016 as custom projects are included in the scope of the CPSV study.

3.1 Summary of Data Collection

Table 12 summarizes the CPSV data collection efforts for the Union Custom C&I programs. The table shows the portion of the program that:

- Completed on-site visits
- Completed telephone-supported engineering reviews (TSER)
- Did not respond to an evaluation attempt at contact
- Was not contacted by the evaluation team.[7]

The data collected is represented as the number of sites, the number of measures, and cumulative ex ante natural gas savings (ex ante CCM). The proportion of the program in each category is also represented in Figure 3. In the figure, size categories within segments (eg. Industrial) are ordered with 1 being the smallest stratum within each segment. The full sample design and achievement by strata can be found in

[6] Previous rounds of CPSV have included Low Income Multi-family custom projects in the evaluation. This evaluation did not include LI MF. For clarity, we will continue to use the Market Rate Multi-family term throughout this report.

[7] Sites or measures where contact was not attempted were either not selected for contact in sampling or in the backup sample or were not contacted due to strata quotas being met.

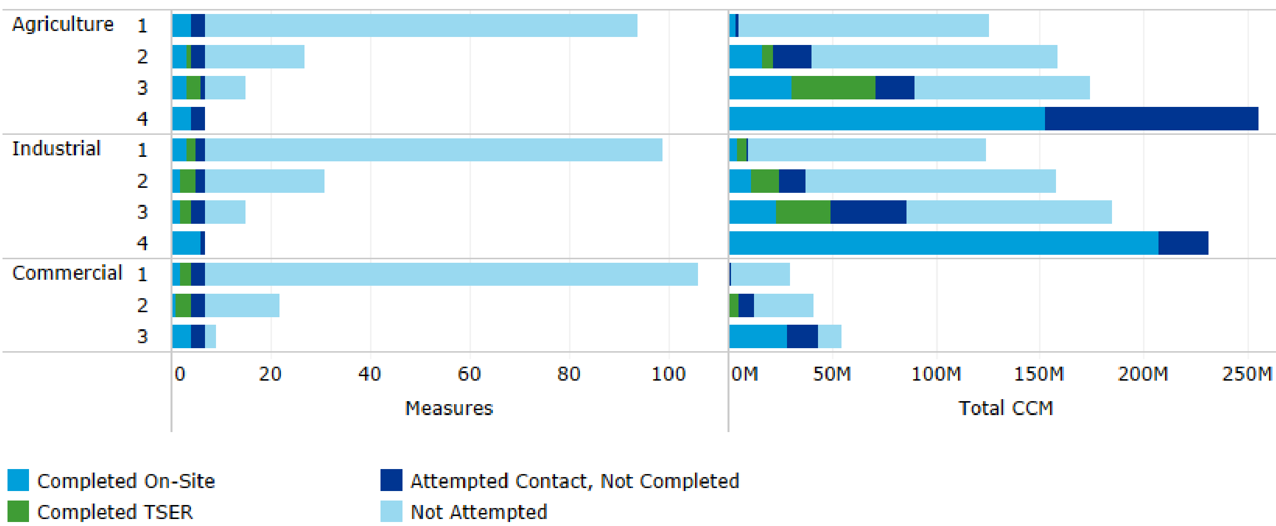
Table 31 in Appendix A. By collecting data on all sampled measures at a site rather than only the first selected, the evaluation exceeded the targeted number of measures. The study had a customer response rate of 62% and achieved the targeted 90/10 relative precision for the cumulative gross realization rate at the program overall level shown in Table 13.

Table 12: Summary of CPSV data collection for the Union Custom C&I Program*

Data Collection Category	Targeted	Completed		
	# Measures	# Sites	# Measures	Ex Ante CCM
Completed On-Site	44	25	34	479,196,561
Completed TSER		15	16	96,074,417
Attempted Contact, Not Completed		25	27	238,281,964
Not Attempted		246	355	725,040,620
Total		**311**	**432**	**1,538,593,562**

* Please see the glossary for definitions of site and measure.

Figure 3: Summary of CPSV data collection for the Union Custom C&I Program



3.2 Gross Savings Realization Rate

The gross savings realization rate represents the differences in ex post and ex ante savings due to differences in calculation methods, EUL, calculation parameters, or other engineering-related adjustments. Table 13 shows the cumulative gross savings realization rate by segment for the Union Custom C&I program, while Table 14 shows the first-year gross savings realization rate, which is used for calculating lost revenue (LRAM). The table shows the number of units of analysis (n), gross savings realization rate (Ratio), precision at the 90% confidence interval, error ratio, and percent of program savings. The percent of program savings represents the relative contribution that each domain makes to the overall result.

Union's C&I programs overall had a sample weighted 101% cumulative gross realization rate. The segments had variation in cumulative gross realization rates ranging from 99% to 112%, resulting in an overall cumulative gross realization rate of 101%. Together the Agriculture and Industrial segments make up 92% of program savings and had cumulative gross realization rates of 100% and 99% respectively. The

Commercial segment, which includes MR MF projects, had a realization rate of 112% and was 8% of savings. Relative precision for the program overall was 6% at 90% confidence.

Table 13: Cumulative gross savings realization rate for the Union Custom C&I program

Sector	n		Ratio	90% Confidence Interval				Error Ratio	% Program Savings
	Measures	Sites		+ / -	Lower Bound	Upper Bound	Relative Precision		
Agriculture	18	9	100.10%	10%	90%	110%	10%	0.20	46%
Commercial	12	12	112.45%	26%	86%	138%	23%	0.45	8%
Industrial	20	19	99.20%	8%	91%	108%	8%	0.21	45%
Overall*	**50**	**40**	**100.53%**	**6%**	**95%**	**107%**	**6%**	**0.24**	**100%**

*Overall ratio in this table is the sample weighted average and is not used in calculating gross savings for the programs.

The first-year savings realization rates vary somewhat from the cumulative gross savings realization rates, with Agriculture and Industrial segments being a little higher and the Commercial segment a little lower. First-year savings differ from cumulative gross savings primarily due to being based on a ratio of annual rather than cumulative savings.

Table 14: First-year gross savings realization rate for the Union Custom C&I program

Sector	n		Ratio	90% Confidence Interval				Error Ratio	% Program Savings
	Measures	Sites		+ / -	Lower Bound	Upper Bound	Relative Precision		
Agriculture	18	9	101.07%	7%	94%	108%	7%	0.16	46%
Commercial	12	12	109.59%	26%	83%	136%	24%	0.47	8%
Industrial	20	19	102.66%	7%	96%	109%	6%	0.16	45%
Overall*	**50**	**40**	**102.24%**	**5%**	**97%**	**107%**	**5%**	**0.19**	**100%**

*Overall ratio in this table is the sample weighted average and is not used in calculating gross savings for the programs.

Cumulative gross savings for the program are shown in Table 15.

Table 15: Verified gross savings CCM results for the Union Custom C&I program

Program	Claimed Savings	Effective Gross Realization Rate	Verified Gross Savings
Agricultural	714,290,651	100.10%	715,004,942
Commercial	125,860,716	112.45%	141,530,375
Industrial	698,442,195	99.20%	692,854,657

3.3 Discrepancy Summary

This section presents detailed results of the various discrepancies between ex ante and ex-post savings. The final realization rate for the program was close to 100%, but the verification found discrepancies in 70% of the projects reviewed. The realization rate and pattern of adjustments indicate that there was not a systemic bias in utility savings estimates to either over or under estimate savings for this program.

Table 16 shows that 15 of the 50 measures had no adjustment, while 35 measures were adjusted based on verification findings. Eighteen of the 35 adjustments were small: verified savings were within 20% of utility tracked savings. Of the 35 adjusted measures 17 had adjustments increasing savings (adjustment greater than 100%)and 18 decreasing savings (adjustment less than 100%).

Table 16: Adjustment Summary – Union Custom C&I

Effect of Adjustment on Utility Tracked Savings	Size of Adjustment	Number of Measures	Percent of Measures
Increase	Small (100% < Adj. < 120%)	9	18%
	Large (Adj. > 120%)	8	16%
	Total	**17**	**34%**
Decrease	Small (80% < Adj. < 100%)	9	18%
	Large (Adj. < 80%)	9	18%
	Total	**18**	**36%**
No Change	Adj. = 100%	15	30%
Grand Total		**50**	**100%**

Four randomly selected examples of measures with large adjustments are described below. They are included here in order to provide readers with examples of the types of differences that can be identified through the CPSV process. Examples described reference the site ID, which is also used in Figure 4 in this section and Table 62 in Appendix F.

Examples of large adjustments that resulted in increased utility savings (adjustments greater than 120%).

- The sampled measure at site UO037 was measure that recovers (re-uses) heat from a process to reduce gas consumption. The ex post savings (verified savings) for the measure were 175% of the ex ante (utility tracked) savings. The reason for discrepancy between the ex ante and ex post savings was that the verification was able to include more post-measure production data in its analysis. These data and the verification engineer's interview with the customer showed that production had increased due to exogenous factors, leading to more gas savings than anticipated at the time the measure was installed.
- The sampled measure at site UO145 was a replacement of deteriorated dock door seals on a heated loading dock. The ex post savings for the measure were 150% of the ex ante savings. The ex post analysis found that the ex ante measure life of 10 years was not consistent with Union's measure life guide. The verification increased the measure life from 10 to 15 years to match Union's measure life guide

Examples of large adjustments that resulted in decreased utility savings (adjustments less than 80%).

- The sampled measure at site UO077 was a combination of HVAC system control logic upgrades and leaking steam valve replacements. The ex post savings for the measure were 40% of the ex ante savings. The verification found three discrepancy sources:
    - Measure life was reduced from 20 to 11.5 years. The verification used a savings weighted measure life to account for different measure lives for the two components of the measure.

- Ex ante savings assumed a 100% leakage rate for steam valves replaced. Verification assumed that the replaced valves had 66% leakage rate based on a study provided to the verification team by Enbridge.
- Ex ante analysis contained an algebraic error in VFD savings analysis (part of the HVAC system control saving estimate). The verification corrected the error.

- The sampled measure at site UO144 was exhaust heat recovery measure (re-circulation of heated air that would otherwise be exhausted after a process). The verification found that the air flow rate used in the ex ante savings estimate was higher than the system was designed to provide and measured air flow rates provided by the customer to the verification team were lower than designed. Ex post savings estimates used the average air flow rate provided by the customer. The verification also found a different operating schedule than was used in ex ante estimates. Where ex ante assumed operation 24/7 (24 hours a day/7 days a week), the verification found that there was a portion of the winter where the site operated the equipment 24/6. Ex post savings estimates used the verified operating schedule.

Figure 4 plots the ex ante tracked cumulative savings and the realization rate for each measure in the sample. The plot is sorted with the smallest measure on the left and largest on the right. The upper plot shows the relative size of each measure. The lower plot shows the realization rate for each measure. In both plots, measures with green bars have a realization rate greater than 100% (verified savings greater than utility tracked savings). Measures with blue bars represent a realization rate less than 100% (verified savings lower than utility tracked savings).

The plot provides a high-level view of the individual site findings and shows that there was not a systematic bias to savings estimates based on measure size.

Figure 4: Sample Measure Realization Rates sorted by size – Union Custom C&I program

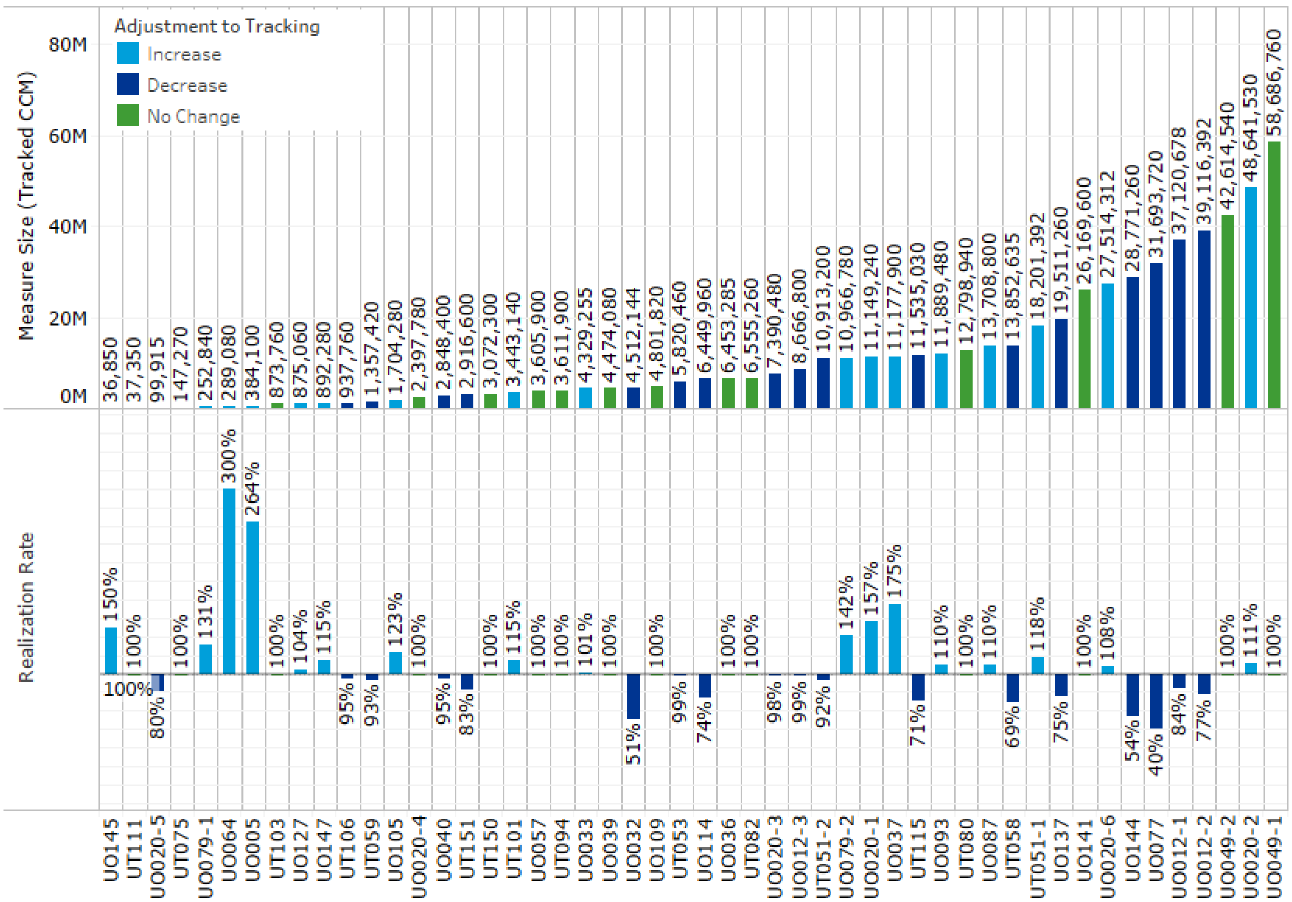


Figure 5 shows the types of discrepancies found by the verification. The verification found no discrepancies for 30% of sampled measures. The major categories of discrepancies were energy efficient measure operating conditions, measure life and interactivity, each of which were a reason for adjustment for 20-30% of measures in the sample.

More complete documentation of energy efficient measure operating conditions by the utility could reduce the frequency of this type of discrepancy, but this type of discrepancy is in part outside the utility's control (see recommendations in section 6.3).

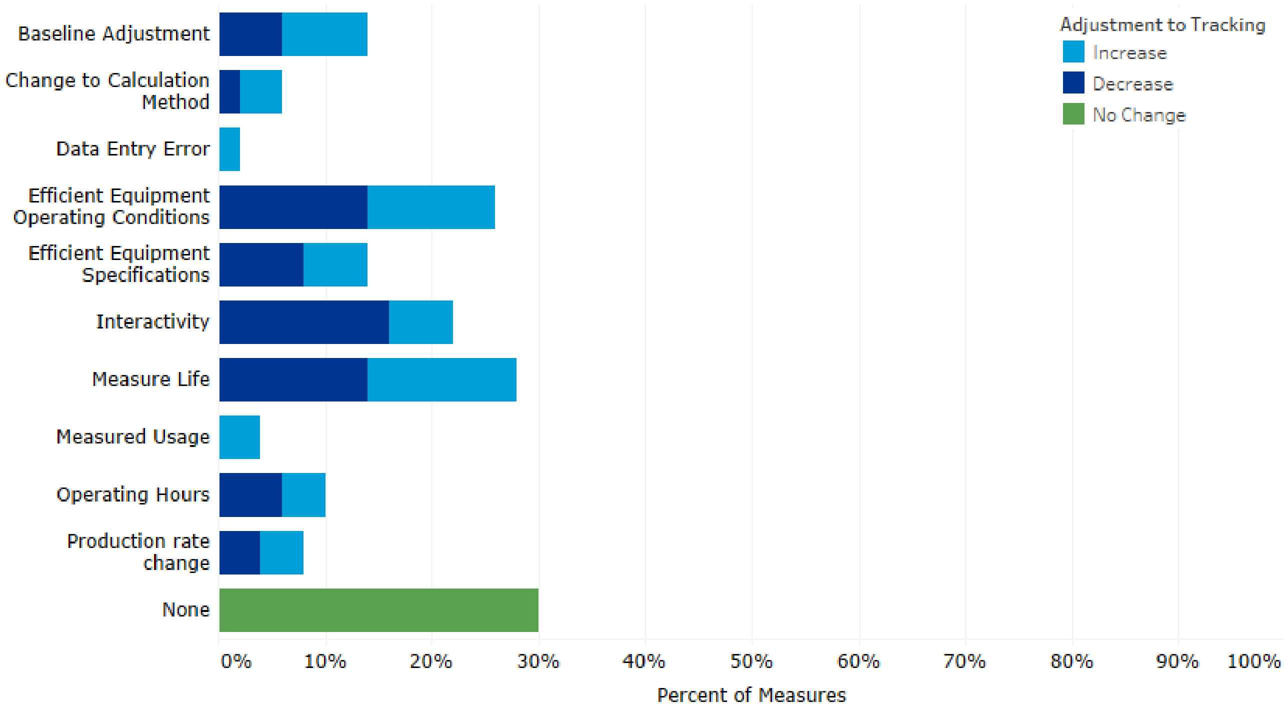
In the case of measure life adjustments, there were two primary reasons:

1. Small changes to measure life caused by a change to savings-weighted average measure life for a bundle of measures in Virtual Grower when the savings for one or more measures was adjusted for equipment operating conditions or specifications found through the verification.
2. A change in boiler measure life from the 20 years assumed by Union in its custom measure life table to 25 years, which is consistent with Enbridge's measure life table and a more reasonable estimate for these measures.

The program can reduce its risk of adjustment for interactivity by making an explicit check in its QC process to review if multiple measure installations at a site have been appropriately accounted for in savings estimates (see recommendation 9 in section 6.1).

In each discrepancy category we found both increases and decreases in savings, which, combined with the overall realization rate near 100% is evidence that the program estimates are not systematically biased.

Figure 5: Savings discrepancies - Union Custom C&I



4 UNION LARGE VOLUME

Union encourages the adoption of energy efficient equipment, technologies, and actions through direct customer interaction via its Large Volume program. The Large Volume program in 2016 was applicable to customers in Rate T2/Rate 100.

The program uses a direct access budget mechanism for the customer incentive budget process. This mechanism grants each customer direct access to the customer incentive budget they pay in rates. Customers must use these funds to identify and implement energy efficiency projects, or lose the funds which will consequently become available for use by other customers in the same rate class. This "use it or lose it" approach ensures each customer has first access to the amount of incentive budget funded by their rates. The Large Volume program is the only "direct access" program offered in Ontario.

Custom projects implemented as part of this program and claimed in 2016 were included in the CPSV study. There were eight (8) prescriptive projects in the 2016 Large Volume program that are not included in CPSV.

4.1 Summary of Data Collection

Table 17 summarizes the CPSV data collection efforts for Union Large Volume. The table shows the portion of the program that:

- Completed on-site visits
- Did not respond to an evaluation attempt at contact
- Was not contacted by the evaluation team.[8]

The data collected is represented in Table 17 as the number of sites, the number of measures, and cumulative ex ante natural gas savings (ex ante CCM). The proportion of the program in each category is also represented in Figure 6. In the figure, size categories are ordered with 1 being the smallest stratum. The full sample design and achievement by strata can be found in Table 32 in Appendix A. By collecting data on all sampled measures at a site rather than only the first selected, the evaluation exceeded the targeted number of measures. The study had a customer response rate of 67% and achieved the targeted 90/10 relative precision for the cumulative gross realization rate at the program overall level shown in Table 18.

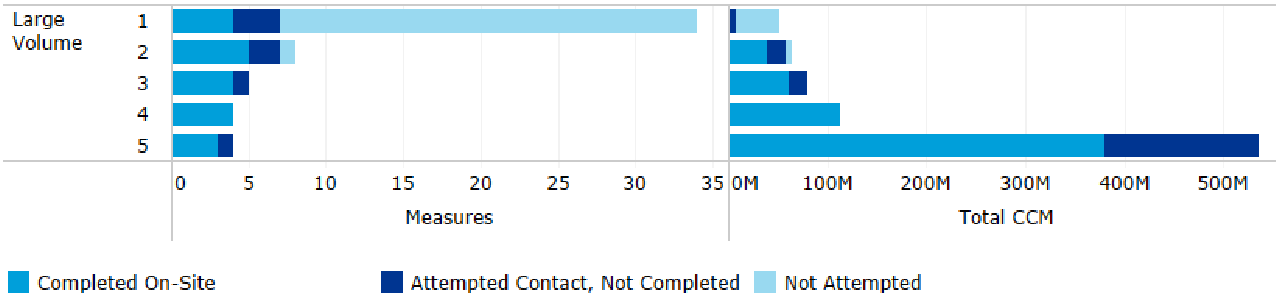
Table 17: Summary of CPSV data collection for Union Large Volume*

Data Collection Category	Targeted	Completed		
	# Measures	# Sites	# Measures	Ex Ante CCM
Completed On-Site	18	10	20	596,108,908
Attempted Contact, Not Completed		5	7	198,476,837
Not Attempted		11	28	50,149,795
Total		**26**	**55**	**844,735,540**

* Please see the glossary for definitions of site and measure.

[8] Sites or measures where contact was not attempted were either not selected for contact in sampling or in the backup sample or were not contacted due to strata quotas being met.

Figure 6: Summary of CPSV data collection for Union Large Volume



4.2 Gross Savings Realization Rate

The gross savings realization rate represents the differences in ex post and ex ante savings due to differences in calculation methods, EUL, calculation parameters, or other engineering-related adjustments. Table 18 shows the cumulative gross savings realization rate for the Union Large Volume program while Table 19 shows the first-year gross savings realization rate, which is used for calculating lost revenue (LRAM). The table shows the number of units of analysis (n), gross savings realization rate (Ratio), precision at the 90% confidence interval, error ratio, and percent of program savings. The percent of program savings represents the relative contribution that each domain makes to the overall result.

The Union Large Volume program overall had a 101% cumulative gross realization rate and a 104% first-year gross realization rate. Relative precision for the program overall was 10% at 90% confidence.

Table 18: Cumulative gross savings realization rate for the Union Large Volume program

Sector	n		Ratio	90% Confidence Interval				Error Ratio	% Program Savings
	Measures	Sites		+ / -	Lower Bound	Upper Bound	Relative Precision		
Large Volume	20	10	100.98%	10%	91%	111%	10%	0.24	100%

First-year savings differ from cumulative gross savings primarily due to being based on a ratio of annual rather than cumulative savings.

Table 19: First-year gross savings realization rate for the Union Large Volume program

Sector	n		Ratio	90% Confidence Interval				Error Ratio	% Program Savings
	Measures	Sites		+ / -	Lower Bound	Upper Bound	Relative Precision		
Large Volume	20	10	103.92%	4%	100%	108%	4%	0.10	100%

Cumulative gross savings for the program are shown in Table 20.

Table 20: Verified gross CCM savings results for the Union Large Volume program

Program	Claimed Savings	Effective Gross Realization Rate	Verified Gross Savings
Large Volume	844,735,540	100.98%	853,013,948

4.3 Discrepancy Summary

This section presents detailed results of the various discrepancies between ex ante and ex-post savings. The final realization rate for the program was close to 100%, but the verification found discrepancies in 70% of the projects reviewed. The realization rate and pattern of adjustments indicate that there was not a systemic bias in utility savings estimates to either over or under estimate savings for this program.

Table 21 shows that 5 out of 20 measures had no adjustment, while 15 measures were adjusted based on verification findings. Eleven of the 15 adjustments were small: verified savings were within 20% of utility tracked savings. Of the 15 adjusted measures 7 had adjustments increasing savings (adjustments greater than 100%) and 8 decreasing savings (adjustment less than 100%).

Table 21: Adjustment Summary – Union Large Volume

Effect of Adjustment on Utility Tracked Savings	Size of Adjustment	Number of Measures	Percent of Measures
Increase	Small (100% < Adj. < 120%)	5	25%
	Large (Adj. > 120%)	2	10%
	Total	**7**	**35%**
Decrease	Small (80% < Adj. < 100%)	6	30%
	Large (Adj. < 80%)	2	10%
	Total	**8**	**40%**
No Change	Adj. = 100%	5	25%
Grand Total		**20**	**100%**

The four measures with large adjustments are described below. Projects described include the site ID in parentheses for reference to Figure 7 in this section and Table 63 in Appendix F.

Two measures had large adjustments that resulted in increased utility savings (adjustments greater than 120%).

- UO007-2 was one of two measures completed at site UO007. The measure consisted of removing scale from the inside of a heat exchanger. This saves gas by improving heat transfer rate of the heat exchanger raising the input temperature of water into a gas-fired steam boiler. The ex post savings (verified savings) for the measure were 499% of the ex ante (utility tracked) savings. The ex post savings are higher than ex ante due to two factors:
    - The customer reported to the verification team that the system operated for more hours than were used in the ex ante calculation
    - The customer provided information that supported a longer measure life than assumed in the ex ante savings estimate (4 years in ex post, 1 year in ex ante).
- UO028-2 was one of two measures completed at site UO028. The measure consisted of replacing worn out insulation on an industrial furnace. The ex post savings for the measure were 174% of the ex ante savings. The ex post savings are higher than ex ante due to two factors:

- The customer provided a full year of post-measure production and gas consumption data to the verification team whereas the utility estimate was based on a partial year (a full year had not passed when the utility finalized its estimates). The change in data increased savings by 5%.
- The customer and manufacturer each provided information that supported a longer measure life than assumed in the ex ante savings estimate (5 years in ex post, 3 years in ex ante).

Two measures large adjustments that resulted in decreased utility savings (adjustments less than 80%).

- UO140-1 was one of two measures completed at site UO140. The measure consisted of replacing a steam pipe system. The ex post savings (verified savings) for the measure were 59% of the ex ante (utility tracked) savings. The ex post savings are lower than ex ante due to two factors:
  - The verification found that an exogenous change had eliminated gas use for part of the system prior to the change in piping. The utility included this gas use as part of the savings.
  - The utility used an unsupported 25-year measure life in ex ante savings estimate, while the verification used the Union measure life guide’s “All other industrial equipment” value of 20 years
- UO131-2 was one of two measures completed at site UO131. The measure consisted of cleaning furnace tubing that results in improved heat transfer for heat exchangers that feed heat into a natural gas fired process. The ex post savings (verified savings) for the measure were 70% of the ex ante (utility tracked) savings. The ex post savings are lower than ex ante due to two factors:
  - The customer provided information that supported a lower load factor than that used in the ex ante savings estimate.
  - The customer provided information that supported a shorter measure life than assumed in the ex ante savings estimate (8 years in ex post, 10 years in ex ante).

Figure 7 plots the ex ante tracked cumulative savings and the realization rate for each measure in the sample. The plot is sorted with the smallest measure on the left and largest on the right. The upper plot shows the relative size of each measure. The lower plot shows the realization rate for each measure. In both plots, measures with green bars have a realization rate greater than 100% (verified savings greater than utility tracked savings). Measures with blue bars represent a realization rate less than 100% (verified savings lower than utility tracked savings).

The plot provides a high-level view of the individual site findings and shows that there was not a systematic bias to savings estimates based on measure size.

Figure 7: Sample Measure Realization Rates sorted by size –Union Large Volume

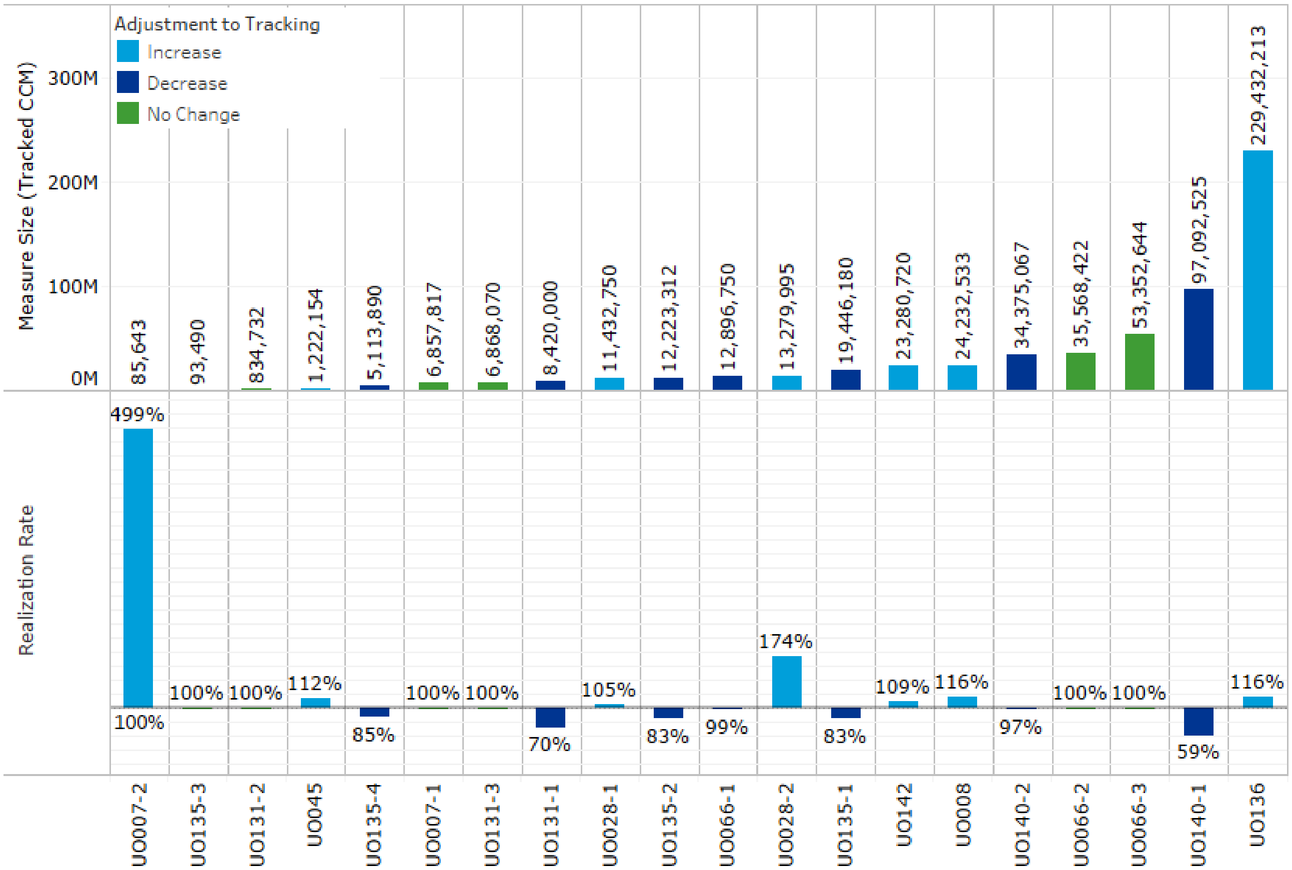
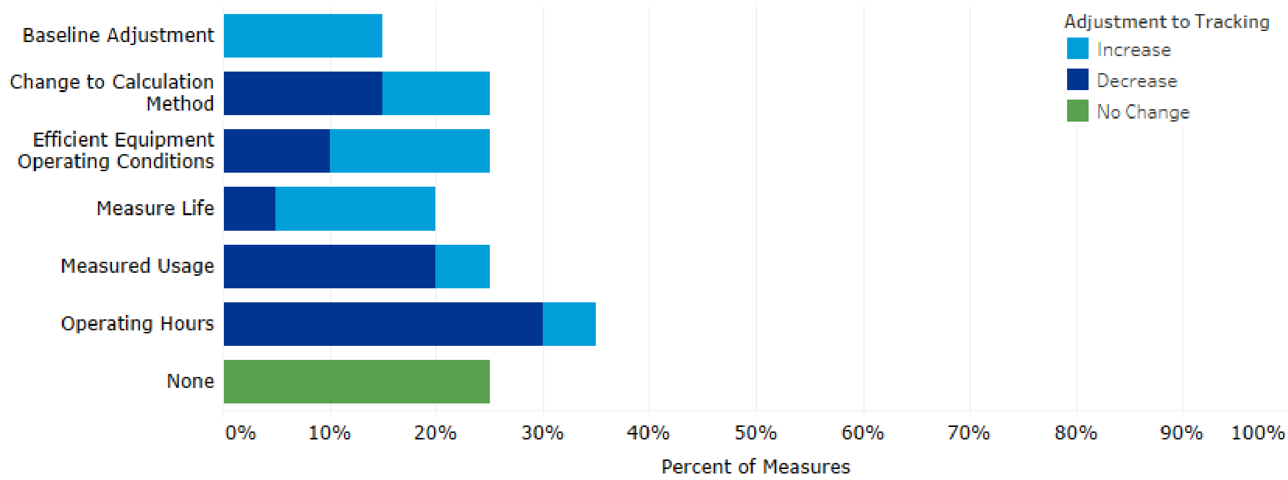


Figure 8 shows the types of discrepancies found by the verification. Seventy-five percent of measures had an adjustment, with the most common reason being different operating hours found by the verification. Operating hours can change after installation, making it hard for programs to reduce risk of adjustment for this reason.

In each discrepancy category we found both increases and decreases in savings, which, combined with the overall realization rate near 100% is evidence that the program estimates are not systematically biased.

Figure 8: Savings discrepancies - Union Large Volume



5 ENBRIDGE COMMERCIAL, INDUSTRIAL, AND MULTI-RESIDENTIAL PROGRAMS

Custom programs for commercial and industrial customers have been designed to encourage commercial and industrial customers to reduce their energy consumption by providing customer-specific energy efficiency and conservation solutions. The custom programs provide financial incentives, technical expertise, and guidance with respect to energy related decision making and business justification, including helping customers to prioritize energy efficiency projects against their own internal competing factors and demonstrate the competitive advantage customers can gain through efficiency upgrades. These custom programs differ from the prescriptive programs as they provide tailored services and varying financial incentives based on overall natural gas savings realized by the customer to address customer-specific needs. Custom program performance is measured in cumulative gas savings (CCM), also known as total lifetime savings.

Enbridge's 2016 Draft Annual Report describes the goal of the Commercial Custom offer as to "promote energy efficiency and to reduce natural gas use through the capture of energy efficiency opportunities in commercial buildings, including retrofits of building components and upgrades at the time of replacement. The objective is to provide technical support, business support services, and financial incentives to help customers meet energy efficiency and budgetary goals."

Enbridge's 2016 Draft Annual Report describes the goal of the Industrial Custom offer as "designed to capture cost-effective energy savings within the industrial sector by delivering customized energy solutions, including providing technical and financial support to customers. Industrial ESCs focus on assisting customers with the adoption of energy efficient technologies by overcoming financial, knowledge or technical barriers. This offer provides engineering technical support, business support services, and financial incentives to help customers meet production, energy efficiency, and budgetary needs."

A subset of the projects in these programs is part of the multi-family or multi-residential segment. In this report we refer to these projects as Market-Rate Multi-family (MR MF) in order to distinguish them from the low income multi-family (LI MF).[9]

All projects implemented as part of these programs and claimed in 2016 are custom projects and are included in the scope of the CPSV study.

5.1 Summary of Data Collection

Table 22 summarizes the CPSV data collection efforts for the Enbridge Custom C&I and Market Rate Multi-Family programs. The table shows the portion of the program that:

- Completed on-site visits
- Completed telephone supported engineering reviews (TSER)
- Did not respond to an evaluation attempt at contact
- Was not contacted by the evaluation team.[10]

[9] Previous rounds of CPSV have included Low Income Multi-family custom projects in the evaluation, though they were not included in the scope for 2016 CPSV. For clarity, we will continue to use the Market Rate Multi-family term throughout this report.

[10] Sites or measures where contact was not attempted were not selected for contact in sampling or in the backup sample.

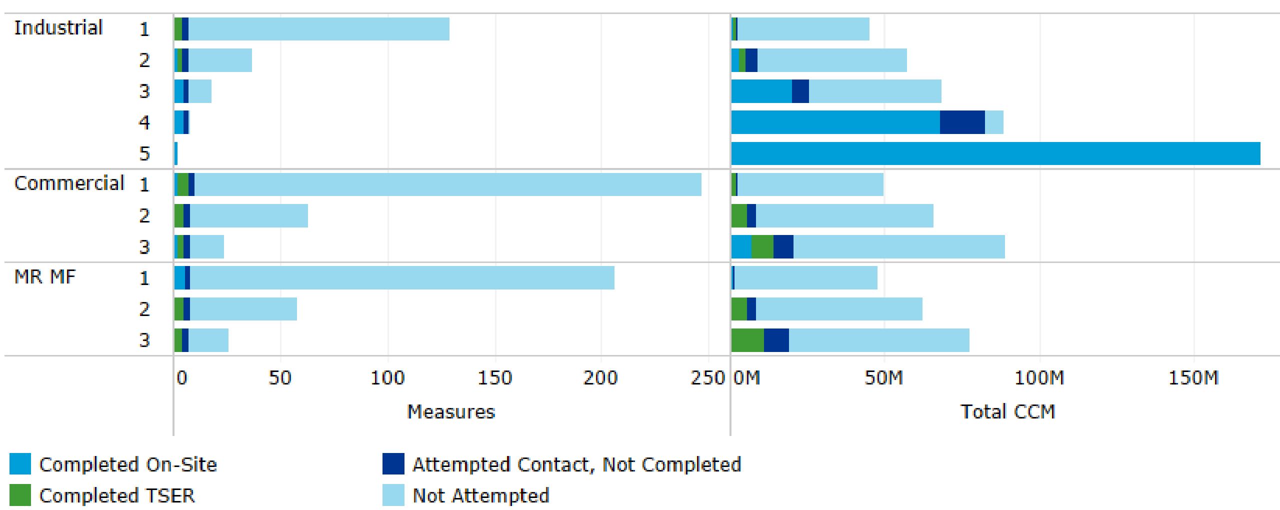
The data collected is represented as the number of sites, the number of measures, and cumulative ex ante natural gas savings (ex ante CCM). The proportion of the program in each category is also represented in Figure 9. In the figure, size categories within segments (eg. Industrial) are ordered with 1 being the smallest stratum within each segment. The full sample design and achievement by strata can be found in Table 33 in Appendix A. By collecting data on all sampled measures at a site rather than only the first selected, the evaluation exceeded the targeted number of measures. The study had a customer response rate of 63% and achieved the targeted 90/10 relative precision for the cumulative gross realization rate at the program overall level shown in Table 23.

Table 22: Summary of CPSV data collection for Enbridge CI&MF*

Data Collection Category	Targeted	Completed		
	# Measures	# Sites	# Measures	Ex Ante CCM
Completed On-Site	48	20	26	272,996,175
Completed TSER		25	26	32,994,580
Attempted Contact, Not Completed		26	27	46,592,039
Not Attempted		531	739	472,555,371
Total		**602**	**818**	**825,138,165**

* Please see the glossary for definitions of site and measure.

Figure 9: Summary of CPSV data collection for Enbridge CI&MF



5.2 Gross Savings Realization Rate

The gross savings realization rate represents the differences in ex post and ex ante savings due to differences in calculation methods, EUL, calculation parameters, or other engineering-related adjustments. Table 23 shows the cumulative gross savings realization rate by domain for the Enbridge Custom C&I and MF program while Table 24 shows the first-year gross savings realization rate, which is used for calculating lost revenue (LRAM). The table shows the number of units of analysis (n), gross savings realization rate (Ratio), precision at the 90% confidence interval, error ratio, and percent of program savings. The percent of program savings represents the relative contribution that each domain makes to the overall result.

Enbridge's C&I and MF program overall had a sample weighted 109% gross realization rate. These domains were found to have variation in gross realization rate ranging from 96% to 114%, resulting in an overall gross realization rate of 109%. The largest segment for these programs is the industrial segment. Relative precision for the program overall was 7% at 90% confidence.

Table 23: Cumulative gross savings realization rate for the Enbridge Custom C&I program

Sector	n		Ratio	90% Confidence Interval				Error Ratio	% Program Savings
	Measures	Sites		+/-	Lower Bound	Upper Bound	Relative Precision		
Commercial	17	16	96.80%	10%	87%	107%	11%	0.25	25%
Industrial	20	16	113.47%	13%	100%	127%	12%	0.28	52%
MR MF	15	13	112.10%	13%	100%	125%	11%	0.24	23%
Overall	**52**	**45**	**109.24%**	**8%**	**101%**	**117%**	**7%**	**0.31**	**100%**

*Overall ratio in this table is the sample weighted average and is not used in calculating gross savings for the programs.

First-year gross realization rates were slightly lower than cumulative gross realization rates for all segments.

Table 24: First-year gross savings realization rate for the Enbridge Custom C&I program

Sector	n		Ratio	90% Confidence Interval				Error Ratio	% Program Savings
	Measures	Sites		+/-	Lower Bound	Upper Bound	Relative Precision		
Commercial	17	16	95.79%	10%	86%	106%	10%	0.24	25%
Industrial	20	16	110.36%	12%	98%	123%	11%	0.27	52%
MR MF	15	13	110.80%	17%	94%	128%	15%	0.33	23%
Overall	**52**	**45**	**106.51%**	**8%**	**99%**	**114%**	**7%**	**0.30**	**100%**

*Overall ratio in this table is the sample weighted average and is not used in calculating gross savings for the programs.

Cumulative gross savings for the program are shown in Table 25.

Table 25: Verified gross CCM savings results for the Enbridge Custom C&I program

Program	Claimed Savings	Effective Gross Realization Rate	Verified Gross Savings
Commercial	204,979,463	96.80%	198,420,119
Industrial	431,638,126	113.47%	489,779,784
MR MF	188,520,576	112.10%	211,331,570

5.3 Discrepancy Summary

This section presents detailed results of the various discrepancies between ex ante and ex-post savings. The final realization rate for the program was close to 100%, but the verification found discrepancies in 77% of the projects reviewed. The realization rate and pattern of adjustments indicate that there was not a systemic bias in utility savings estimates to either over or under estimate savings for this program.

Table 26 shows that 9 of the 52 measures had no adjustment, while 43 measures were adjusted based on verification findings. Nineteen of the 43 adjustments were small: verified savings were within 20% of utility tracked savings. Of the 43 adjusted measures 22 had adjustments increasing savings (adjustment greater than 100%) and 21 decreasing savings (adjustment less than 100%).

Table 26: Adjustment Summary – Enbridge Custom C&I

Effect of Adjustment on Utility Tracked Savings	Size of Adjustment	Number of Measures	Percent of Measures
Increase	Small (100% < Adj. < 120%)	9	17%
	Large (Adj. > 120%)	13	25%
	Total	**22**	**42%**
Decrease	Small (80% < Adj. < 100%)	10	19%
	Large (Adj. < 80%)	11	21%
	Total	**21**	**40%**
No Change	Adj. = 100%	9	17%
Grand Total		**52**	**100%**

Four randomly selected examples of measures with large adjustments are described below. They are included here in order to provide readers with examples of the types of differences that can be identified through the CPSV process. Projects described include the site ID in parentheses for reference to Figure 10 in this section and Table 64 in Appendix F.

Examples of large adjustments that resulted in increased utility savings (adjustments greater than 120%).

- EO013-2 was one of two measures completed at site EO013. The measure consisted of the installation of on/off controls for a humidification system. This allowed the system to be turned off during non-production hours. The ex post savings (verified savings) for the measure were 297% of the ex ante (utility tracked) savings. The ex post savings are higher than ex ante due to four factors:
    - The customer reported to the verification team that the system operated for more hours than were used in the ex ante calculation
    - The utility calculator had an incorrect hard coded value for baseline operating hours (corrections resulted in an increase in ex post savings relative to ex ante)
    - The utility calculator used a value from a steam table that was misread (correcting this resulted in a small increase in ex post savings relative to ex ante)
    - The utility used an unsupported 15-year measure life in ex ante savings estimate, while the verification used the Enbridge measure life guide's "Industrial Process" value of 20 years.
- The sampled measure at site ET046 was installation of five dock door seals on a heated warehouse where no dock door seals had been installed previously. The ex post savings for the measure were 162% of the ex ante savings. The ex post savings are higher than ex ante due to two factors:
    - The customer reported to the verification team that the warehouse operates for more hours during the heating season than were used in the ex ante calculation.

- The customer reported to the verification team that temperature setpoint in the affected space was higher than assumed in the ex ante calculation.

Examples of large adjustments that resulted in decreased utility savings (adjustments less than 80%).

- The sampled measure at site EO011 was a ventilation control scheduling measure. Make-up air unit controls settings were modified to reduce flow rates where possible instead of operating at a constant volume. The ex post savings for the measure were 48% of the ex ante savings. The verification found three discrepancy sources, the net effect of which was a reduction in savings:
    - Customer reported a less efficient domestic hot water heat source rather than direct fired. The DHW boiler also had controls installed on it. Interactive savings from these controls were accounted for in the ex post savings, but not the ex ante.
    - The customer's building automation system (BAS) showed higher flowrates during both on and off peak periods.
    - The customer's building automation system (BAS) showed a shorter daily peak period each day.
- EO010-2 was one of two measures completed at site EO010. The measure consisted of filtering and re-using heated process water to avoid heating make up city water. The ex post savings (verified savings) for the measure were 13% of the ex ante (utility tracked) savings. The ex post savings are lower than ex ante due to four factors:
    - The customer reported that it had recently taken steps to close the facility where the measure was installed. This reduced the measure life for the savings from this measure.
    - The customer reported lower water temperatures for the reclaimed heated process water than used in the ex ante estimate (resulting in lower ex post savings relative to ex ante)
    - The customer reported lower boiler make up flow rate than used in the ex ante estimate (resulting in lower ex post savings relative to ex ante)
    - The customer reported higher boiler efficiency than used in the ex ante estimate (resulting in lower ex post savings relative to ex ante)

Figure 10 plots the ex ante tracked cumulative savings and the realization rate for each measure in the sample. The plot is sorted with the smallest measure on the left and largest on the right. The upper plot shows the relative size of each measure. The lower plot shows the realization rate for each measure. In both plots, measures with green bars have a realization rate greater than 100% (verified savings greater than utility tracked savings). Measures with blue bars represent a realization rate less than 100% (verified savings lower than utility tracked savings).

The plot provides a high-level view of the individual site findings and shows that there was not a systematic bias to savings estimates based on measure size.

Figure 10: Sample Measure Realization Rates sorted by size – Enbridge Custom C&I program

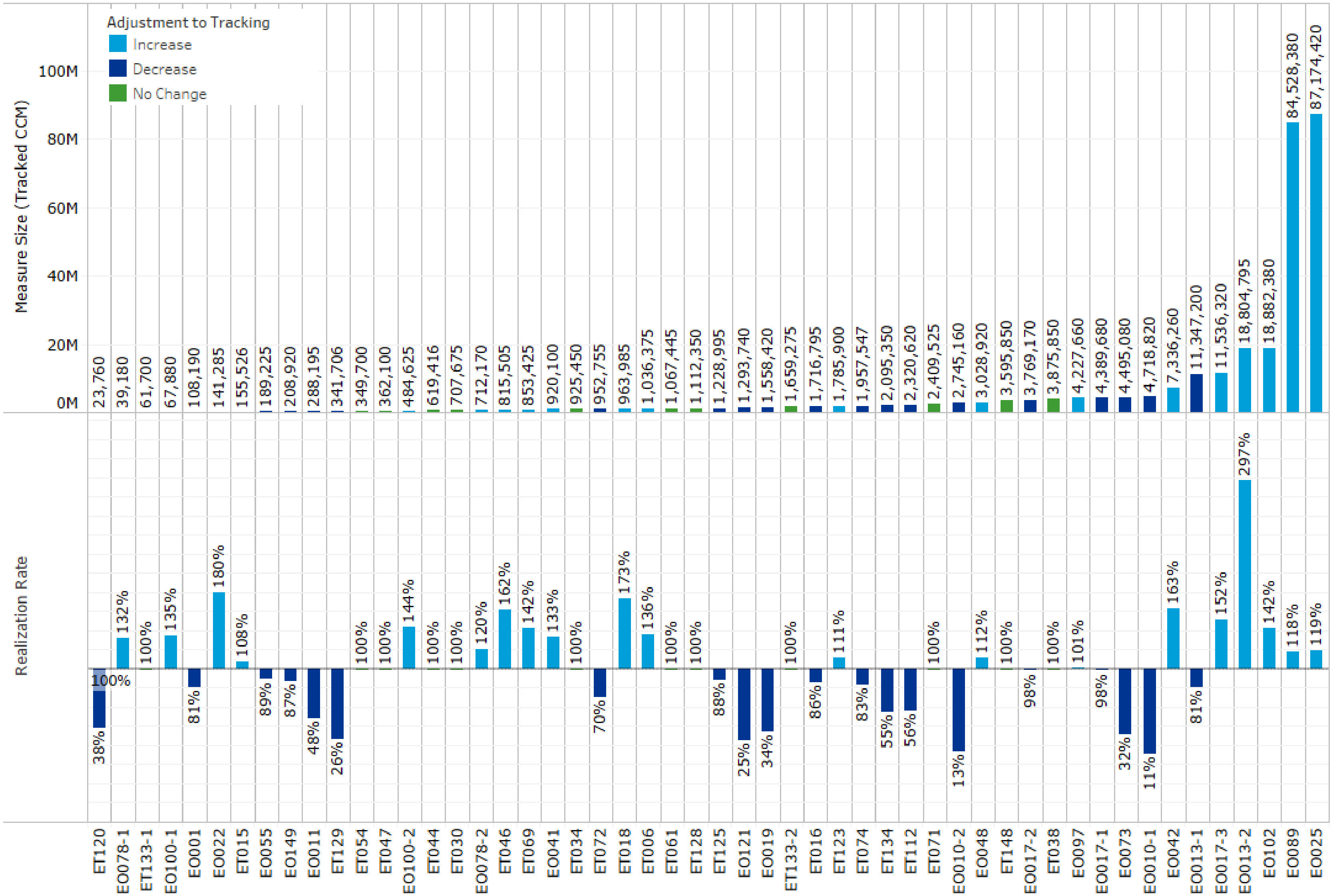
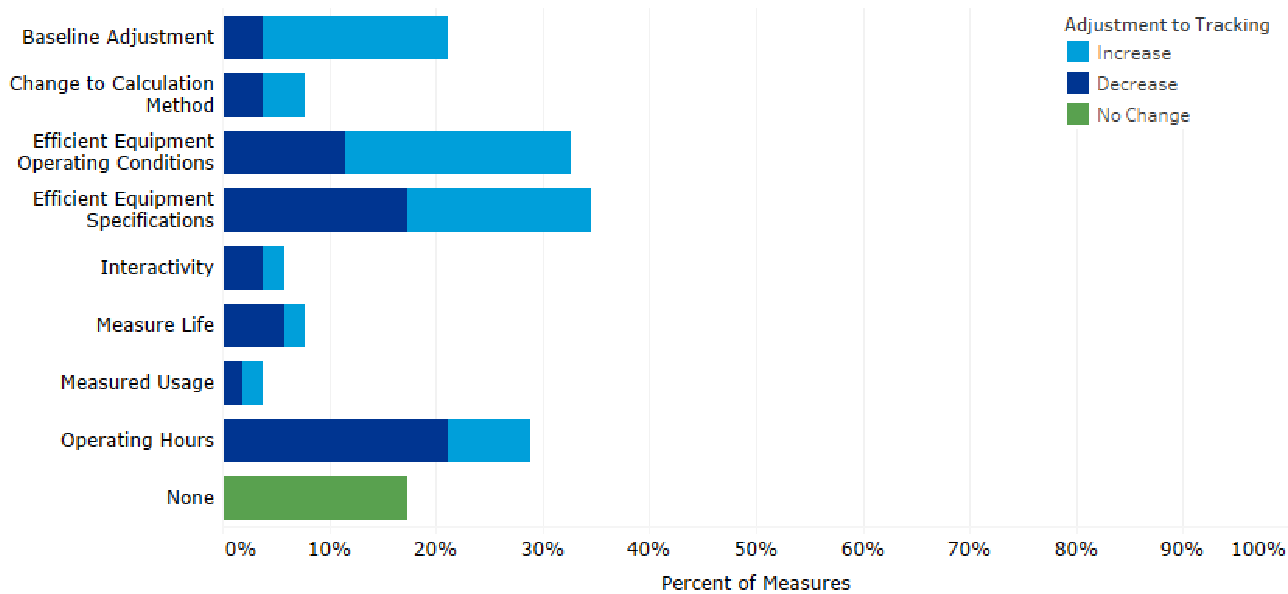


Figure 11 shows the types of discrepancies found by the verification. Operating conditions, efficient equipment specifications and baseline adjustments were three of the most common discrepancies found. The program can reduce each of these types of discrepancies by documenting projects more thoroughly with sources for values used and more complete descriptions of conditions found at the time of installation (see recommendations in section 6.3). While more complete documentation of energy efficient measure operating conditions by the utility could reduce the frequency of this type of discrepancy, but this type of discrepancy is in part outside the utility's control.

In each discrepancy category we found both increases and decreases in savings, which, combined with the overall realization rate near 100% is evidence that the program estimates are not systematically biased.

Figure 11: Savings discrepancies – Enbridge Custom C&I program



6 FINDINGS AND RECOMMENDATIONS

The tables in this section present the key findings and recommendations from the study. The tables show the party to whom the recommendation applies and the primary beneficial outcome of the recommendation. We classified outcomes into four categories: reduce costs, increase savings, increase (or maintain) customer satisfaction and decrease risk (multiple types of risk are in this category including risk of adjusted savings, risk to budgets or project schedules, and others). Details of the findings, recommendations and outcomes follow the tables.

Table 27: Energy savings and program performance recommendations

#	Energy Savings and Program Performance		Applies to			Primary Beneficial Outcome			
	Finding	Recommendation	Union	Enbridge	Evaluation	Reduce Costs	Increase Savings	Increase Customer Satisfaction	Decrease Risk
1	Both utilities exhibit a strong commitment to accurate energy savings estimate	The utilities should continue in their commitment to accuracy.	✓	✓				✓	✓
2	The CPSV effort found realization rates near 100% and identified adjustments for most projects.	Continue performing custom savings verification on a regular basis.			✓				✓
3	Relative precision targets were met or surpassed for all programs	Use error ratio assumptions from the results provided in this report in future evaluation years, but with more conservative bounding than performed this year.			✓	✓			✓
4	Some measures have difficult-to-define baseline technologies.	Establish a policy to define rules around energy savings calculation for fuel switching and district heating/cooling measures.	✓	✓	✓				✓
5	Review of documentation for gross evaluation showed that several projects were high free rider risks.	Review projects with large incentives for free ridership risk. Develop clear program rules that allow the utility to reject free rider projects.	✓	✓			✓		✓

#	Energy Savings and Program Performance		Applies to			Primary Beneficial Outcome			
	Finding	Recommendation	Union	Enbridge	Evaluation	Reduce Costs	Increase Savings	Increase Customer Satisfaction	Decrease Risk
6	Influence adjustments were made to projects that adjusted the gross savings for "net" or program influence reasons.	Increase transparency of "influence adjustments" and do not include in gross savings	✓				✓	✓	✓
7	There is not a clear policy to determine "standard" baselines.	Establish a clear policy to determine and define "standard" baselines	✓	✓	✓	✓			✓
8	Some measures in each utility program are routine maintenance or periodic repairs that are considered standard care in other jurisdictions.	Establish a clear policy regarding eligibility of maintenance and repair measures for the programs.	✓	✓	✓	✓			✓
9	The programs did not consistently account for interactivity among measures.	Add an interactivity check to the programs' internal QC process for savings estimates.	✓	✓	✓	✓			✓

Table 28: Verification process recommendations

#	Verification Process		Applies to			Primary Outcome			
	Finding	Recommendation	Union	Enbridge	Evaluation	Reduce Costs	Increase Savings	Increase Customer Satisfaction	Decrease Risk
10	DNV GL was unable to obtain access to all the equipment at all the sites selected for verification.	Modify contracts to require participants to agree to comply with EM&V as part of the requirements for participation in the program.	✓	✓		✓			✓
11	Future evaluations should consider large HVAC to be high rigour rather than standard rigour.	Consider large HVAC measures for higher rigour verification.			✓				✓

Table 29: Documentation and Support recommendations

#	Documentation and Support		Applies to			Primary Outcome			
	Finding	Recommendation	Union	Enbridge	Evaluation	Reduce Costs	Increase Savings	Increase Customer Satisfaction	Decrease Risk
12	Incremental improvement in project documentation by both utilities was observed in the 2016 CPSV. Project documentation for some projects lacked sufficient details to allow evaluators to reproduce the calculations made by program staff or third-party vendors.	Take steps to improve documentation: • Implement an electronic tracking system that archives all materials • Include explicit sources for all inputs and assumptions in the project documentation. • Store background studies and information sources with the project files and make them available to evaluators. • Provide evaluators full access to customer data. • Provide pre- and post-installation photos, where available. • Document and provide internal M&V documents where available. • Institute a checklist as part of project closeout to ensure all relevant project documentation is assembled as ready for verification	✓	✓			✓		✓

#	Documentation and Support		Applies to			Primary Outcome			
	Finding	Recommendation	Union	Enbridge	Evaluation	Reduce Costs	Increase Savings	Increase Customer Satisfaction	Decrease Risk
13	Explanations of complex projects were not consistently clear making it hard to understand what process is producing energy savings.	Improve clarity and details of documentation explaining the source of energy savings for complex projects.	✓	✓					✓
14	Ex ante savings estimates based on annual energy consumption for industrial sites did not always include sufficient information documenting production.	Include site production totals in relevant years in the savings estimates based on annual energy consumption for industrial sites	✓	✓					✓
15	Enbridge Boilers use a 73% assumed thermal efficiency for in situ boilers that have been in place for more than 10 years.	Estimate boiler degradation from name plate efficiency to determine the baseline boiler efficiency rather than a flat number	✓	✓					✓
16	Pipe insulation is a significant source of savings for the Union Gas programs. Documentation for the source of factors used in calculations and of in situ conditions was not consistently provided.	Document baseline conditions of pipe insulation (and other measures) using photos and text descriptions to provide context. Explicitly tie the documentation of baseline condition to the heat loss rate used for the savings calculation.	✓	✓					✓

#	Documentation and Support		Applies to			Primary Outcome			
	Finding	Recommendation	Union	Enbridge	Evaluation	Reduce Costs	Increase Savings	Increase Customer Satisfaction	Decrease Risk
17	Enbridge documentation did not always include a prose explanation and supporting documentation for baseline types (ROB, ER) and remaining useful life (RUL).	Always complete the "Base Case Overview" in the form with a prose description of the base case. The description should reference included emails and photos to document in situ conditions and features that are carried over into the baseline system.		✓					✓
18	The utilities should use longer duration data in ex ante savings estimates when possible.	Use longer duration data in ex ante savings estimates. When time periods less than a year are used, documentation should be provided to indicate why the period used is applicable to a full year and why a full year was not able to be used.	✓	✓		✓			✓
19	In situ boiler name plate information, age and operating condition are all helpful for determinizing the designed performance and reasonable range of actual efficiency for the system as well as providing context to better determine remaining useful life (RUL)	Document in situ boiler name plate information, age and operating condition for all projects where boiler efficiency affects savings	✓	✓					✓

#	Documentation and Support		Applies to			Primary Outcome			
	Finding	Recommendation	Union	Enbridge	Evaluation	Reduce Costs	Increase Savings	Increase Customer Satisfaction	Decrease Risk
20	Items that may be obvious to the ex ante team can be non-obvious to an outside party.	Review ex ante documentation from an outside perspective to help identify gaps	✓	✓					✓
21	At large sites with multiple spaces containing similar equipment, ex ante documentation did not always identify which space or piece of equipment was affected by the project.	Include additional descriptions of spaces and equipment affected to differentiate among similar spaces and equipment at the site.	✓	✓					✓
22	Invoices were not always included with documentation, and sources for incremental costs were not always clear.	Ensure that incremental costs are supported by invoices or other documentation, especially for add-on and optimization measures where the total cost and incremental cost are likely to be the same.	✓	✓				✓	✓
23	Larger projects appeared to fall under the same documentation standards as smaller projects.	Increase the amount of documentation and source material for projects that have greater energy savings.	✓	✓					✓

#	Documentation and Support		Applies to			Primary Outcome			
	Finding	Recommendation	Union	Enbridge	Evaluation	Reduce Costs	Increase Savings	Increase Customer Satisfaction	Decrease Risk
24	Union's custom project summary workbook is a good approach to documentation. The workbook is not used in a consistent manner across all projects.	Consider providing more training or adding quality control steps to ensure the summary workbook front page is completed and stored in a consistent manner. Identify a common approach for common measures and, if necessary, document deviations and the reasons for the deviations in a clearly labelled field on the summary sheet.	✓			✓			✓
25	Enbridge Etools does not sufficiently document sources of inputs and assumptions.	Use a consistent summary workbook.		✓		✓			✓

Table 30: Data management recommendations

#	Data Management		Applies to			Primary Outcome			
	Finding	Recommendation	Union	Enbridge	Evaluation	Reduce Costs	Increase Savings	Increase Customer Satisfaction	Decrease Risk
26 A	Neither Union nor Enbridge currently track participating customer or participating vendor contact information in their program tracking	Track contacts associated with projects in the program tracking database.	✓	✓		✓		✓	✓
26 B		Strongly consider investing in relational program tracking databases.	✓	✓		✓	✓	✓	✓

#	Data Management		Applies to			Primary Outcome			
	Finding	Recommendation	Union	Enbridge	Evaluation	Reduce Costs	Increase Savings	Increase Customer Satisfaction	Decrease Risk
26 C	database. Providing the information to the evaluation puts significant burden on utility staff. In 2016, the data provided by utility staff was much more consistent and clear relative to 2015.	Continue to use improved structure for data integrity in the evaluator request for contact information for the 2017 savings verification and evaluation.			✓	✓		✓	
27	The extracts from the utility program tracking database do not include dates for key project milestones.	Track and provide to evaluators dates for key milestones in the project.	✓	✓		✓			✓
29	EUL and cumulative gross savings were not provided in a consistent manner in the Enbridge program tracking database extract	Include separate fields in the program tracking database for all components of gross and net cumulative and first year savings.	✓	✓			✓		✓

6.1 Energy savings and program performance

1. **Finding:** Both utilities exhibit a strong commitment to accurate energy savings estimates. Both utilities have made significant investments in developing calculation tools which model savings accurately. For example, Union's dock door seal calculator is well considered and designed, and Enbridge's Etools calculator is very thorough in attempting to model savings for key measures.

   Both utilities chose to retain engineers with strong understanding of their customers' building and process systems and showed a commitment to finding accurate savings estimates. On several occasions, both on the phone and in writing, the evaluation team suggested a value that would have increased savings in a way that the utility program engineer did not think was valid. When this happened, neither utility was shy in suggesting that we may want to make a more conservative choice.

Recommendation: The utilities should continue in their commitment to accuracy.

Outcome: Accurate energy savings.

2. **Finding:** The CPSV effort this year found realization rates near 100% and identified adjustments for most projects. Across the programs a near equal number of adjustments increased and decreased savings and one third of projects had a large adjustment (verified savings more than 20% different from tracked).

   Recommendation: Continue performing custom savings verification on a regular basis. Even a study that results in an adjustment of near 100% is still valuable because the programs know that their savings estimates will be reviewed. Knowing a review will be conducted improves the quality of ex ante estimates. The review itself also results in information that improves future program savings estimates.

   Outcome: Accurate energy savings.

3. **Finding:** Relative precision targets were met or surpassed for all programs. The sample design incorporated the previous year's error ratios (ERs) and averaged them with the assumption used in 2015. ERs were further bounded (minimum ER was 0.25, maximum 0.60) to limit the risk of over- or under- collecting data. There was one segment (Union Commercial) where precision was not as good as expected.

   Recommendation: The process used to develop error ratios assumptions from the results provided in this report should be continued in future evaluation years, possibly with more conservative bounding (potentially increasing the maximum ER) to avoid under-collection of data for any segments.

   Outcome: Realistic estimates of error ratios result in an appropriate amount of data collected to meet targets.

4. **Finding:** Some measures (e.g., geothermal heat pumps, combined heat and power, and those that save district heating energy) have difficult-to-define baseline technologies. Multiple different baselines are possible for these projects depending on how one looks at the scope of the project: how non-gas energy changes and offsite gas use are considered in savings estimates are two of the challenging aspects.

   Recommendation: Consider establishing a policy to define rules around energy savings calculations and baselines for fuel switching and district heating/cooling measures.

   Outcome: Less risk of adjustment and a better alignment between province energy efficiency goals and program implementation.

5. **Finding:** Through the gross verification process, we reviewed project documentation and had conversations with customers about their installed measures. While the focus of this report is not on net savings, we did observe a handful of projects (out of the 122 evaluated) that appeared to be clearly at high risk for free ridership. These projects included maintenance type measures, projects that were far along in planning prior to utility involvement, projects with very short paybacks, and projects that included significant non-energy benefits.

   Recommendation: Review projects with large incentives for free ridership risk. Develop clear program rules that allow the utility to reject free rider projects.

   Outcome: Increased savings, reduced risk of free ridership, more efficient use of program funds.

6. **Finding:** Union made influence adjustments to projects that adjusted the gross savings for "net" or program influence reasons. Accounting of which projects had these adjustments was not maintained by Union and the adjustments were included in different places in project calculation workbooks, making their identification and validation challenging. In addition, the program NTG was also applied to these projects, effectively double discounting savings in scorecards.

   Recommendation: If Union chooses to continue making influence adjustments to the savings upon which it calculates savings, it should make these adjustments more transparent and exclude them from the reported gross savings for the program in scorecards. Instead the specific project influence adjustment should be included in the scorecard in place of the general program or domain level NTG factor.

   Outcome: Reduced risk of double adjustments.

7. **Finding:** There is not a clear policy to determine what standard to use for replace on burnout or new construction baselines. The 2016 verification used a code or minimum available baseline where required, in alignment with the 2015 net-to-gross study. Without a clear policy there is uncertainty for all stakeholders as to what the appropriate baseline should be. This uncertainty affects all aspects of the programs, including what measures are offered, what incentives are paid and how measures are evaluated.

   Recommendation: Establish a clear policy to determine and define baseline standards where an "industry standard" baseline would be applicable.

   Outcome: Consistency of approach across utilities, evaluators and studies will reduce risk of adjustment and evaluation cost.

8. **Finding:** Some measures in each utility program are routine maintenance or periodic repairs that are considered standard care in other jurisdictions.

   Recommendation: Establish a clear policy regarding eligibility of maintenance and repair measures for the programs.

   Outcome: Reduced free ridership risk.

9. **Finding:** The programs did not consistently account for interactivity among measures. In several cases, we saw an overestimation of the combined boiler efficiency improvement yielded by the addition of linkageless controls and condensate heat recovery measures and an overestimation of savings for subsequent measures that interact with earlier measures within the same program year.

   Recommendation: Add an interactivity check to the programs' internal QC process for savings estimates.

   Outcome: More accurate savings estimates and a reduced evaluation risk.

6.2 Verification processes

10. **Finding:** DNV GL was unable to obtain access to all the equipment at all the sites selected for verification. Both Enbridge and Union have several large projects with industrial companies, including food processing, refineries, and other industries. In many cases, the customer refused to provide SCADA (Supervisory Control and Data Acquisition) system data or similar trend data to allow a reasonable

verification of the project. This means we were unable to do more than a reasonableness check on the savings.

A review of the Enbridge contract shows that the customer is not required to provide the information that is necessary for EM&V. The most relevant sections are:

Item 6: Payment of the Incentive Payment is subject to the completion of a satisfactory site inspection of the improvements, including the installed equipment by an authorized representative of Enbridge.

Item 9: Upon request within eighteen months of the commissioning date of the Project, and with reasonable notice, the Customer agrees to provide authorized representatives of Enbridge with access to the Project, and with required information or data relating to the project for the purposes of the Application and these General Terms and Conditions.

Neither of these are sufficient for EM&V.

Recommendation: Modify contracts to require participants to agree to comply with EM&V as well as utility representatives as part of the requirements for participation in the program.

Outcome: Reduced evaluation costs and risks. Participant non-compliance requires evaluators to request documentation for a large backup sample, and to survey and/or visit additional sites to obtain sufficient data for the evaluation. The process of contacting a site and getting a refusal costs time and money, as does the substitution of an additional site to make up for the unobtained data. In some cases, there might not be additional sites to sample, in which case the evaluation estimates will have lower precision than they would with full compliance.

11. **Finding:** Large HVAC and HVAC controls projects proved more complex to evaluate than planned.

    Recommendation: Future evaluations should consider large HVAC to be high rigour rather than standard rigour.

    Outcome: Better alignment of rigour with uncertainty will improve accuracy of savings estimates and provide more cost-effective evaluation.

6.3 Documentation and support

12. **Finding:** Incremental improvement in project documentation by both utilities was observed in the 2016 CPSV. Project documentation for some projects lacked sufficient details to allow evaluators to reproduce the calculations made by program staff or third-party vendors. Specific issues included:

    - Project data or details missing
    - Insufficient measure-level details to fully describe what was installed
    - Descriptions that were difficult to understand
    - Use of black box tools
    - Hardcoded information in calculation spreadsheets
    - Undocumented assumptions
    - Sources referenced but not included or available, such as feasibility studies and historical analysis of energy use that was left out of the project documentation
    - Input adjustments that approximate other effects, but are not explained
    - Insufficient access to customer data (by customers).

- Modelling files that could not be opened
- Adjustments to savings estimates for safety or influence that were not clearly marked, sourced, or carried out in a consistent fashion

Recommendation: Improve data quality. Possible steps include:

- Implement an electronic tracking system that archives all materials
- Include explicit sources for all inputs and assumptions in the project documentation.
- Store background studies and information sources with the project files and make them available to evaluators.
- Provide evaluators full access to customer data.
- Provide pre- and post-installation photos, where available.
- Document and provide internal M&V documents where available.
- Institute a checklist as part of project closeout to ensure all relevant project documentation is assembled as ready for verification

Outcome: Properly explaining and sourcing the savings calculation method and assumptions allows the evaluating engineer to more easily identify what needs to be verified. It also makes it easier to determine whether the methods and assumptions are reasonable and use ex ante assumptions rather than seek documented values elsewhere.

13. **Finding:** Explanations of complex projects were not consistently clear making it hard to understand what process is producing energy savings. This was seen with large HVAC control projects with MUAs, AHUs, heat recovery projects, and custom process projects, and others.

    Recommendation: Improve the documentation/explanation of the source of energy savings for complex projects that are related to complex systems. Use figures, diagrams, and equations as needed, especially for cascading or multi-staged measures. Parameters such as the heating source, and the efficient case peak and off-peak period flowrates and schedules should be recorded and sourced. If there are additional units not included in the measure, these should be documented and considered in savings estimates (even if the effect is zero).

    Outcome: Increased accuracy of savings estimates. Reduced evaluation risk.

14. **Finding:** Ex ante savings estimates based on annual energy consumption for industrial sites did not always include sufficient information documenting production. The change in energy use pre- and post-measure is sensitive to changes in production.

    Recommendation: Savings estimates based on annual energy consumption for industrial sites should include information from the site on amount of production in the years used. It's not enough to say "not much is changed, they run 24/7". If detailed production data are not available, the utilities should get percentage differences year to year (e.g.: if year 1=100%; is year 2 exactly the same, or is it 95% or 110% of production the previous year).

    Outcome: Documenting production changes and using them in savings estimates will improve accuracy and reduce evaluation risk.

15. **Finding:** Enbridge Boilers use a 73% assumed thermal efficiency for in situ boilers that have been in place for more than 10 years. This is based on a 2% de-rate of a 2007 combustion efficiency study that

found an average combustion efficiency of 74.6% for 39 boilers aged 12-38 years (average 24.5). The study, which EGD provided to the evaluation team, did not attempt to tie the degraded combustion efficiency to the original rated efficiency of the boilers. The study is also now more than 10 years old, so its findings are likely out of date and should only at most apply to 20-year-old or more boilers. For 2016, the evaluation used the 73% value since a better option was unavailable at the time.

Recommendation: Use a degradation from name plate efficiency to determine the baseline boiler efficiency rather than a flat number. The 2017 CPSV effort should include in the scope secondary research to determine a degradation factor or curve to be used for the 2017 and 2018 CPSV and could be incorporated by the utilities for the 2019 program year until primary research is completed or a better approach is developed.

Outcome: Improving this key assumption will improve savings estimates for a significant portion of savings in the Enbridge portfolio and the process would also be applicable to Union sites where baseline boiler efficiencies are required and not based on site tests of boiler performance.

16. **Finding:** Pipe insulation is a significant source of savings for the Union Gas programs. Union estimates heat loss rate for damaged baseline insulation less than that from a simple bare pipe assumption, which is reasonable and appropriate. Documentation for the source of the factors used in the calculation and documentation (via photos and/or a description of the pipe insulation condition) was not consistently provided.

    Recommendation: Document baseline conditions using photos and text descriptions to provide context. Tie the documentation of baseline condition to the heat loss rate used in a clear way.

    Outcome: Improving documentation of baseline conditions and clarity in calculations will reduce evaluation risk improve consistency of approach among the Union engineering team.

17. **Finding:** Enbridge documentation did not always include a prose explanation and supporting documentation for baseline types (ROB, ER) and remaining useful life (RUL). "See Etools for base case" is not sufficient: Etools is not designed to provide context and sources to support the values included.

    Recommendation: Always complete the "Base Case Overview" with a prose description of the base case. The description should reference included emails and photos to document in situ conditions and features that are carried over into the baseline system.

    Outcome: Improved descriptions and documentation will reduce evaluation risk and help Enbridge ensure that accurate information has been entered into Etools.

18. **Finding:** Duration of pre- post- data (energy consumption, production output, raw material consumption, etc.) used for savings estimates were too brief in several instances.

    Recommendation: The utilities should use longer duration data in ex ante savings estimates when possible. When time periods less than a year are used, the utilities should document why the period used is applicable to a full year and why a full year was not able to be used.

    Outcome: Increased accuracy of savings estimates.

19. **Finding:** The utilities did not always gather boiler nameplate data for in situ systems. The age and operating condition was also not always recorded or described. This was a concern on boiler projects,

but also for projects where boiler efficiency has an effect on savings, such as greenhouses, pipe insulation and heat recovery.

Recommendation: In situ boiler name plate information, age and operating condition are all helpful for determinizing the designed performance and reasonable range of actual efficiency for the system as well as providing context to better determine remaining useful life (RUL)

Outcome: Improving documentation of the in situ boiler will reduce uncertainty in savings estimates and reduce evaluation risk.

20. **Finding:** Items that may be obvious to the ex ante team can be non-obvious to an outside party. Examples from sites this year included in situ burners that could not be turned off and whether heating needs were equal to or greater than the amount of heat recovered.

    Recommendation: Review ex ante documentation from an outside perspective to identify where documentation or explanation could be added.

    Outcome: Reduced evaluation risk.

21. **Finding:** At large sites with multiple spaces containing similar equipment, ex ante documentation did not always identify which space or piece of equipment was affected by the project.

    Recommendation: Include additional descriptions of spaces and equipment affected to differentiate among similar spaces and equipment at the site.

    Outcome: Reduced evaluation risk.

22. **Finding:** Invoices were not always included with documentation, and sources for incremental costs were not always clear.

    Recommendation: Ensure that incremental costs are supported by invoices or other documentation, especially for add-on and optimization measures where the total cost and incremental cost are likely to be the same. Equipment replacement measures may require an additional standard efficiency quote to produce incremental cost.

    Outcome: Incremental cost is an important component of simple payback, which is often used to judge the economic benefit of energy efficiency projects. It is also an input to some benefit-cost tests.

23. **Finding:** Larger projects appeared to fall under the same documentation standards as smaller projects.

    Recommendation: Increase the amount of documentation and source material for projects that have greater energy savings.

    Outcome: Projects that are better documented tend to have more accurate savings estimates and receive fewer evaluation adjustments than those that are less documented. Large projects have a greater effect on overall savings adjustment factors. Therefore, large projects with better documentation are more likely to result in adjustment factors closer to 100%.

24. **Finding:** Union custom projects utilized a project application summary workbook that summarizes the key project inputs, calculations, and most details. In general, this is a good approach that facilitates internal review and evaluation. We also found that the workbooks had improved source documentation

relative to the 2015 projects. One challenge was that different projects used the workbook in different ways:

- The notes section was sometimes used to identify and highlight specific unique approaches and features in projects, but not always.
- Calculations internal to the summary page were consistent for most projects, but not all (additional factors were sometimes added).
- Sub-methods critical to the calculation were contained in hidden sheets.
- Safety and influence adjustments were inserted in different locations and not always explained.

Recommendation: Consider providing more training or adding quality control steps to ensure the summary workbook front page is completed and stored in a consistent manner. Identify a common approach for common measures and, if necessary, document deviations and the reasons for the deviations in a clearly labelled field on the summary sheet.

Outcome: A consistent summary workbook aids both internal and external quality assurance, quality control, and measurement and verification.

25. **Finding:** Enbridge Etools is used as both a calculation tool and as a communication tool with customers. While it appears to serve the needs of the program, this form of communication is difficult for the evaluation efforts.

- Etools does not easily allow for assumptions to be sourced within the record.
- Some Etools selections may be site-specific and some may be defaults; the calculator does not distinguish.
- Energy savings that are calculated outside of Etools are hard-entered in Etools but not always sourced.

Recommendation: Use a consistent summary workbook.

Outcome: A consistent summary workbook aids both internal and external quality assurance, quality control, and measurement and verification.

6.4 Data management

27. **Finding:** Neither Union nor Enbridge currently track participating customer or participating vendor contact information in their program tracking database. Providing the information to the evaluation puts significant burden on utility staff. In 2016, the data provided by utility staff was much more consistent and clear relative to 2015.

Recommendation A: Track contacts associated with projects in the program tracking database. At a minimum, the program tracking database should include:

- Project site address
- Customer mailing address
- Primary customer contact name
- Primary customer contact phone
- Primary customer contact email
- Primary customer contact mailing address

- Addresses are best tracked as multiple fields including:
  - Street address line 1
  - Street address line 2
  - City
  - Province
  - Postal code

Phone number fields should include data validation to enforce a consistent format and avoid missing or extra digit errors. Phone extensions should be tracked in a field separate from the ten-digit phone number and be restricted to numeric data only.

The best practice is to maintain contacts in a table separate from specific project or customer data. This allows for a single contact to be connected to multiple accounts and/or projects as necessary without creating duplication. This structure also makes it easier to associate multiple contacts with a single project, and decreases quality control costs.

Vendor contact information should also be tracked in the database, in the same table as the participating customer contact information. With a relational database, the contact ID from the table can be added to a project record in the role consistent with the contact's participation (such as vendor, decision maker, or technical expert) with a separate table that allows a single vendor contact to be associated with multiple projects.

Outcome A: Reduced burden on utility staff to seek contact information for projects, whether for internal or evaluation use. Reduced evaluation costs and improved sample design expectations.

Recommendation B: The utilities should strongly consider investing in relational program tracking databases. Relational program tracking databases and customer relationship management (CRM) systems allow for multiple contacts to be associated with a single account and/or project. The incremental cost of implementation is low if it is part of the initial database design, populated as projects are started, and updated once they are complete.

For the implementation team, a query-able one-stop shop for information provides a wealth of information that can improve delivery. For example, these databases can help programs understand how contractors work across projects, identify when projects have hit snags and need attention, and give the program team access to key customer context such as historical participation, and different contacts that have worked with the program.

For evaluation, this allows programs to easily clarify aspects of projects during implementation and to provide accurate, timely, and usable contact information to evaluators and verifiers.

Outcome B: Improved customer satisfaction from better delivery, and a reduced burden on utility staff for tracking information. A relational database would also streamline aggregation of program data for scorecards and make providing data simpler for annual savings evaluation and verification.

Recommendation C: When the evaluation requests contact information for savings verification and evaluation, the contact request spreadsheet will continue to provide additional fields to enforce data integrity (e.g., specific fields for a parsed address and company name for the technical and decision-making contacts). If the program tracking databases are able to report contact information, this spreadsheet should be modified to reduce burden on utility staff while maintaining high levels of data integrity.

Outcome C: Reduced evaluation costs due to less data cleaning and research to fill missing information. Improved data collection with less returned advance letters and more accurate connection between projects and contacts.

28. **Finding:** The extracts from the utility program tracking database do not include dates for key project milestones. Enbridge's data did not include any dates and Union's included only the "install date."

    Recommendation: Track and provide to evaluators dates for key milestones in the project. Dates for project start, installation, and those that define the program year provide useful context for interviewers that is not always easy to find in project documentation

    Outcome: Improved data collection through more informed interviewers and reduced evaluation costs through less need to search for dates in documentation.

29. **Finding:** EUL and cumulative gross savings were not provided in a consistent manner in the Enbridge program tracking database extract. The EUL inconsistency is the result of a work around for advanced (accelerated) projects used by Enbridge to report accurate dual baseline saving estimates and first year savings. Communicating the workaround consistently within the evaluation team led to some re-work.

    Recommendation: Include separate fields in the program tracking database for:

    - EUL
    - RUL
    - gross first year annual savings
    - gross post-RUL annual savings
    - NTG,
    - gross cumulative gross
    - net cumulative savings
    - net first year savings.

    Outcome: Improved data integrity results in less evaluation risk and more accurate savings totals. Providing each of the key savings types and their components allows evaluation to confirm that the savings provided are internally consistent.

APPENDIX A FINAL SAMPLE ACHIEVEMENT

The tables below (Table 31 to Table 33) show the achieved sample for each stratum in the sample designs. The tables are specific to each program and show the categorical stratification (segment) and size strata (larger numbers are bigger projects). Sampling was done at the measure level. The target column shows the number of units we attempted to complete. The complete column shows the number of measures randomly selected and completed. Percent of frame cumulative savings is the percent of total savings in the sample frame (population studied) in each category. Note that in some cases measures beyond the target were completed. These completed measures were at sites with multiple measures in the sample.

Table 31: CPSV Sample Achievement for Union CI&MF

Segment	Size Stratum	Max CCM Savings	Measures			Percent of Frame CCM Savings	
			Target	Complete	Frame Total	Strata %	% Complete
Agriculture	1	4,261,610	4	4	94	8%	<1%
	2	7,684,892	4	4	27	10%	1%
	3	18,614,920	4	6	15	11%	5%
	4	48,641,530	4	4	7	17%	10%
Industrial	1	3,232,840	4	5	99	8%	<1%
	2	9,619,900	4	5	31	10%	2%
	3	17,016,460	4	4	15	12%	3%
	4	58,686,760	4	6	7	15%	13%
Commercial	1	871,240	4	4	106	2%	<1%
	2	3,523,200	4	4	22	3%	<1%
	3	13,708,800	4	4	9	4%	2%

Table 32: CPSV Sample Achievement for Union Large Volume

Segment	Size Stratum	Max CCM Savings	Measures			Percent of Frame CCM Savings	
			Target	Complete	Frame Total	Strata %	% Complete
Large Volume	1	5,028,828	4	4	34	6%	<1%
	2	14,392,750	4	5	8	8%	5%
	3	23,280,720	3	4	5	9%	7%
	4	35,568,422	3	4	4	13%	13%
	5	229,432,213	4	3	4	63%	45%

Table 33: CPSV Sample Achievement for Enbridge CI&MF

Segment	Size Stratum	Max CCM Savings	Measures			Percent of Frame CCM Savings	
			Target	Complete	Frame Total	Strata %	% Complete
Industrial	1	986,520	4	4	129	5%	<1%
	2	2,582,265	4	4	37	7%	<1%
	3	4,908,156	4	5	18	8%	2%
	4	18,882,380	4	5	8	11%	8%
	5	87,174,420	2	2	2	21%	21%
Commercial	1	619,416	6	7	247	6%	<1%
	2	1,858,425	5	5	63	8%	<1%
	3	8,794,260	5	5	24	11%	<1%
MR MF	1	644,347	5	6	206	6%	<1%
	2	1,760,525	5	5	58	8%	<1%
	3	7,117,525	4	4	26	9%	<1%

APPENDIX B TECHNICAL POLICY APPROACHES

This appendix memorializes some of the more noteworthy topics that arose during the evaluation as part of Evaluation Advisory Committee (EAC) review of CPSV site reports. In many cases these decisions carry forward decisions made during the 2015 CPSV (as noted in the text).

Measure categories and baseline selection

Table 34 shows the CPSV team's definitions of which baseline is appropriate for various situations. These are guidelines that apply to almost all projects. Some situations may require an exception, in which case the reasoning was described in the site report. In most cases where a code or market minimum baseline was an option, we used that rather than a customer specific baseline. This approach was used in order to maintain consistency of approach with the 2015 net-to-gross study, making the results of that study applicable in conjunction with the results from this study.

Table 34: Measure categories and associated baselines

Measure Type	Gross Savings, based on remaining useful life from facility contact and documentation		Examples	Notes
	Early Repl. Baseline	Normal Repl. Baseline		
Replace on Burnout (ROB) and Existing Equipment More Efficient than Code or Where No Code Applies	NA	In-Situ (use new equipment with the same size/rating and in-situ efficiency)	Unique measures where no code/Industry Standard Practice (ISP) exists; Drum Dryers	
Replace on Burnout (ROB) and Existing Equipment Less Efficient than Code	NA	Code/Standard Market Efficiency	Replacing a boiler which was no longer practical to operate	
New Construction (NC) / Capacity Expansion (CE)	NA	Code/Standard Market Efficiency or Minimum on Market/Customer Specific	New boiler for new space or system. Any new construction or natural gas load adding/increasing. Other recently constructed non-participating buildings onsite are a reasonable baseline	Minimum on market / customer specific applies where there is no enforced code
Retrofit Add On (REA)	In-Situ	Code/Standard Market Efficiency or Minimum on Market/Customer-specific	Equipment controls; addition of boiler economizer; pipe/tank insulation	Minimum on market / customer specific applies where there is no enforced code

Measure Type	Gross Savings, based on remaining useful life from facility contact and documentation		Examples	Notes
	Early Repl. Baseline	Normal Repl. Baseline		
Early Replacement (ER) and Existing Equipment More Efficient than Code or Where No Code Applies	In-Situ	In-Situ (use new equipment with the same size/rating and in-situ efficiency)	Greenhouse components, such as a site with degraded double-layer polyethylene walls which then installs triple layer but uses single layer poly walls as the baseline (this is a regressive baseline) to estimate savings. Must use double layer (new not degraded) as the baseline in this case.	
Early Replacement (ER) and Existing Equipment Less Efficient than Code	In-Situ	Code/Standard Market Efficiency or Minimum on Market/Customer Specific	Regenerative Thermal Oxidizer (RTO) – required to meet local air quality emissions requirements, that a recuperative or direct-fired oxidizer cannot achieve.	
Maintenance (Including Repair or Maintain to Code or Restoration to Prior Efficiency Level)	NA	In-Situ	Re-tube boilers to rated efficiency levels; Repair or clean heat exchanger; Replace heat exchanger oil; Rewind motors; Repair or Replace faulty/leaking valves, pipes, ductwork, etc.; Re-pipe condensate return lines.	
System Optimization (OPT)	NA	In-Situ	Revamp Process Control Strategy; De-bottlenecking to increase production and m^3/widget; Modifying the sequence of processes.	

Estimated useful life

The EUL of the new measure applied to all categories of measures:

For most measures, we based EULs on those found in the Utility Measure Life Guide,[11] when present and reasonable. Site contacts were asked about their expectations for the EUL of the measure installed. Whether to use the Utility measure life guide or the site contact information was based on the judgement of the evaluation engineer and a simple decision matrix shown in Table 35.

[11] Union Gas Limited, Enbridge Gas Distribution Inc. (2016, December 21). EB-2016-0246 Joint Summary Table of Measures Assumptions. Toronto.

Table 35: EUL decision matrix

		Is there a measure specific (not other/process) EUL in the utility measure life guide?	
		Yes	**No**
Does site contact provide information that supports an EUL value determination?	**Yes**	Use utility measure life guide unless site contact has site specific reason for EUL value provided	Use site contact reported EUL
	No	Use utility measure life guide	Use utility measure life guide for other/process, ex ante EUL, or, in rare cases, secondary sources such as manufacturers or other studies

When EULs were not present in the Utility Measure Life Guide, and site contacts were not knowledgeable we would then base EULs on those used in other North American jurisdictions. In rare cases, manufacturer information could have been used to determine the applicable EUL for measures that were not found in a survey of EUL guides and TRMs.

The RUL of the existing equipment limited the EUL of the implemented measure for the following categories of measures:

- Retrofit Add-on (REA)
- System Optimization (OPT)
- Maintenance

RUL was determined based on the best available evidence. In some cases, the preponderance of evidence suggested that a REA measure was likely to be re-used with new equipment when the existing equipment was replaced. Evidence to support using an EUL rather than RUL for REA measures required that the re-use was both feasible (REA measure must be compatible with a wide range of substitute equipment) and likely (ISP was re-use for the application and/or site contact indicates that re-use was planned).

There are situations where the RUL of the existing measure is more than likely longer than the EUL of the REA measure. Pipe insulation is an example: in almost all cases we would expect existing pipes to outlast the insulation installed on them.

Site engineers and interviewers used a list of questions to help determine the RUL of existing equipment. Due to time constraints, project specifics and the site contact's willingness/ability to respond, not all questions were asked of all sites. In 2016, we made this process more formalized as detailed below.

The following section provide the methodology we used for determining the applicable RULs. Question wording onsite and on telephone interviews did vary from the language used here as the questions were delivered in the context of the broader conversation about the implemented measures.

Framing Questions

These questions are intended to get the respondent thinking about their rebated equipment in the context of:

- Their broader facility or process
- Their typical maintenance and equipment replacement practices
- The performance of the equipment relative to their current needs

Interviewers should ask these questions before moving to the measure-type-specific questions shown in the following sections.

- For all add-on measures, interviewers should ask these questions of the pre-existing energy using equipment that the add-on measure is reducing load for (host equipment). Wording should be informed by observed equipment condition.
- For add-on measures that replaced a pre-existing add-on interviewers should ask these questions referring to the pre-existing add-on in addition to and separate from the host equipment.
- For replacement measures interviewers should ask these questions referring to the condition of the replaced equipment at the time of replacement.

Maintenance

- frequency
- costs relative to that anticipated for a new unit
- costs over time (are they increasing or decreasing)

Performance

- Is/was it meeting needs?
- performing at its rated specification?
- Degrading more or less quickly between maintenance/repairs?

Any components whose failure would cause replacement of the equipment?

- Which component is it?
- How much longer do you think it will last?

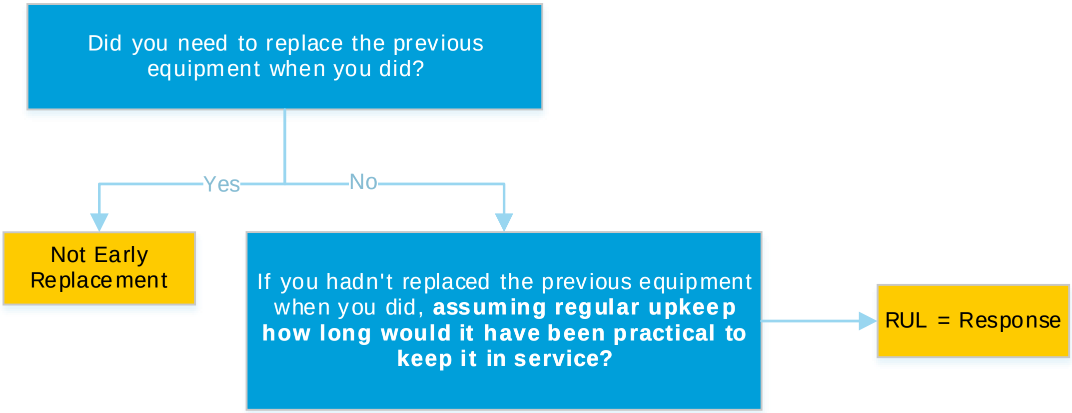
Equipment Replacement

The equipment replacement measure type refers to equipment that is installed in place of another piece of equipment being removed. In this case, the EUL of the installed equipment is split into two periods:

- **ER Period**: This is the period representing the RUL of the existing (replaced) equipment. During this period, the existing equipment is the baseline.
- **Non-ER Period:** The remaining EUL (after subtracting out the RUL) is referred to the non-ER period. During this period, the new standard efficiency baseline shall be used.

We determine the RUL for equipment replacement measures by asking the question shown in Figure 12.

Figure 12. Equipment Replacement Data Collection Flow Chart



It is important to ensure that the respondent understands that regular maintenance and upkeep should be assumed.

Note that the question does not refer to the program. We are trying to understand how long the equipment would have stayed in service had it not been replaced at the time it was. This is different from a timing/acceleration question that might be found in a free ridership question sequence in that the reasons for replacing now rather than later are not material in the gross context.

Put simply, for this gross-only evaluation, we do not care when a customer would have replaced their equipment without the program. Instead we are seeking to understand how much longer it would have been practical to keep the equipment in use.

Add-on Equipment

The add-on equipment measure type refers to equipment that is added to an existing system or piece of equipment to make it more efficient, such as a control or insulation. There are many potential periods within the EUL of the installed add-on equipment. These periods include:

- **ER Period 1**: The period where the existing add-on equipment (or none, if the existing equipment did not have any applicable add-on equipment) and existing host equipment could have continued operating in the same manner. During this period, the baseline would be the existing host equipment with the existing add-on (if any).
- **ER Period 2**: There could be a second ER period on rare occasions, for two reasons:
    - If the existing add-on equipment (if there was one) would have failed or been replaced, but the existing host equipment was still operating effectively. During this period, the baseline would be the existing host equipment with new standard efficiency add-on equipment.[12]
    - If the existing host equipment failed, but the existing add-on equipment could have been used with the new host equipment. During this period, the baseline would be the new host equipment (whatever the customer will most likely install) with the existing add-on equipment.

[12] Note that the "new std. eff. add-on" case may not include an add-on at all. For example, the standard efficiency case for many motors is not to use a motor drive but to allow the motor to run by itself. Sometimes customers even replace an existing VFD-driven motor with one that does not have a VFD.

- **Non-ER Period**: The period after both the existing host equipment and the existing add-on (if any) would have failed or had to have been changed/replaced. During this period, the baseline is the new host equipment with a new standard efficiency add-on.[12]

These periods are represented visually in Figure 13. In this figure, the labels are defined as follows:

- **Exist. Add-on RUL > 0**: Existing add-on equipment was early replacement.
- **Exist. Host RUL > 0**: The add-on was installed on existing host equipment.
- **EUL of New Add-on > RUL of Exist. Host**: The host equipment will be replaced during the life of the new add-on
- **New Add-on Compatible with New Host**: The new add-on equipment is practical to reuse with whatever replaces the existing host equipment, as determined by the questions in Figure 12.

Figure 13. Add-on Equipment Periods

Scenario					<--------------------New Add-on Equipment EUL------------------->		
					Baseline is:		
#	Exist. Add-on RUL >0	Exist. Host RUL >0	EUL of New Add-on > RUL of Exist. Host	New Add-on Compatible with New Host.	ER Period 1	ER Period 2	Non ER Period
1	yes	yes	yes	yes	Exist. Host Pre-exist. Add-on	Exist. Host New Std. Eff. Add-on[12]	New Host New Std. Eff. Add-on[12]
2	yes	yes	yes	no	Exist. Host Pre-exist. Add-on[12]	Exist. Host New Std. Eff. Add-on[12]	No Savings
3	yes	yes	no	-	Exist. Host Pre-exist. Add-on (or none)	n/a	Exist. Host New Std. Eff. Add-on[12]
4	yes	no	-	yes	New Host Pre-exist. Add-on.	n/a	New Host New Std. Eff. Add-on[12]
5	no	yes	yes	yes	Exist. Host New Std. Eff. Add-on[12]	n/a	New Host New Std. Eff. Add-on[12]
6	no	yes	yes	no	Exist. Host New Std. Eff. Add-on[12]	n/a	No Savings
7	no	yes	no	-	n/a	n/a	Exist. Host New Std. Eff. Add-on[12]
8	no	no	-	yes	n/a	n/a	New Host New Std. Eff. Add-on[12]

Using the example of a boiler and a boiler controller, here is how these scenarios would work:

- **Scenario 1:**
  - Customer had an existing boiler with an existing controller.
  - Existing controller and boiler both had an RUL greater than zero.
  - Boiler RUL was greater than the existing controller RUL
  - New controller EUL is greater than the existing boiler RUL
  - Controller would be compatible with a new boiler.
- **Scenario 2**
  - Customer had an existing boiler with an existing controller.
  - Existing controller and boiler both had an RUL greater than zero.
  - Boiler RUL was greater than the existing controller RUL
  - New controller EUL is greater than the existing boiler RUL
  - Controller would not be compatible with a new boiler.
- **Scenario 3**
  - Customer had an existing boiler with an existing controller.
  - Existing controller and boiler both had an RUL greater than zero.
  - Boiler RUL was greater than the existing controller RUL
  - New controller EUL is less than the existing boiler RUL
  - Controller would not be compatible with a new boiler.
- **Scenario 4**
  - Customer had an existing controller which was re-installed on a new boiler.
  - Existing controller had an RUL greater than zero.
  - New boiler EUL is greater than the existing controller EUL
- **Scenario 5**
  - Customer had an existing boiler with an RUL greater than zero.
  - Existing controller had failed or did not exist
  - New controller EUL is greater than the existing boiler RUL
  - Controller would be compatible with a new boiler.
- **Scenario 6**
  - Customer had an existing boiler with an RUL greater than zero.
  - Existing controller had failed or did not exist
  - New controller EUL is greater than the existing boiler RUL
  - Controller would not be compatible with a new boiler.
- **Scenario 7**
  - Customer had an existing boiler with an RUL greater than zero.
  - Existing controller had failed or did not exist
  - New controller EUL is less than the existing boiler RUL
- **Scenario 8**
  - Customer installed a new controller on a new boiler

Additional examples using other technologies:

- **Scenario 1**: A customer replaces damper driven speed control with a VFD on a make-up air (MUA) unit. The customer says that the VFD is easily removable, and could easily be reused on a new MUA. The damper speed control had an RUL of 5 years, the MUA an RUL of 10 years, and the VFD has an EUL of 15 years.

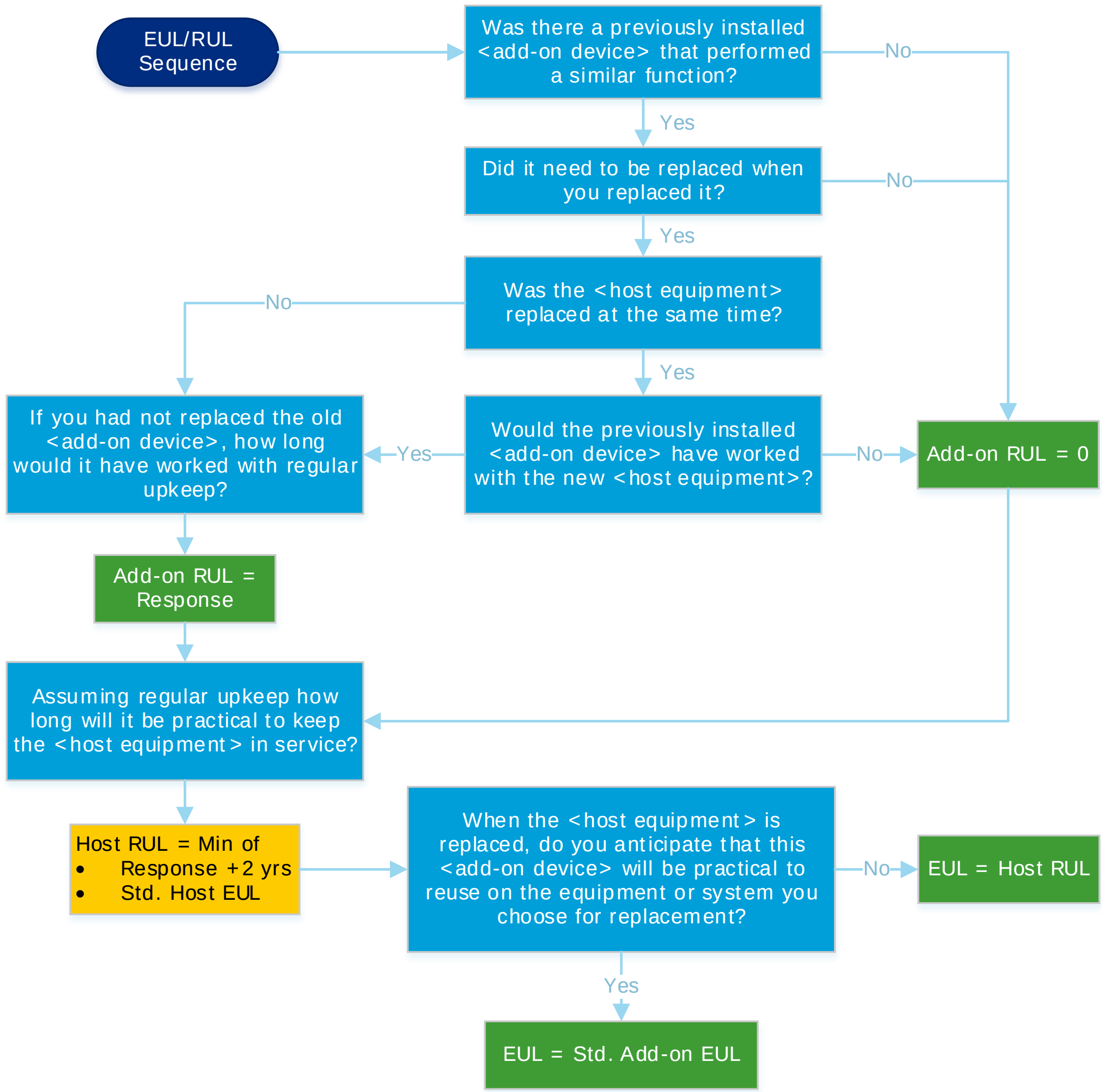
Period	Length (yrs)	Baseline
ER Period 1	5	Exist. Host Exist. Add-on
ER Period 2	5	Exist. Host New Std. Eff. Add-on[12]
Non ER Period	5	New Host New Std. Eff. Add-on[12]

- **Scenario 2**: A customer adds a vendor-specific linkageless control to their existing steam boiler. The existing boiler did not have any similar controls. The customer says that the boiler has an RUL of 5 years. They do not like the existing system vendor, and so in a new system they would not find it practical to recycle the used vendor-specific linkageless control. The linkageless control has a standard EUL of 10 years, though in this case the EUL is limited to 5 years.

Period	Length (yrs)	Baseline
Non ER Period	5	Exist. Host Exist. Add-on[12]

We determine the RUL and EUL for add-on measures by asking the questions shown in Figure 14. The purpose is to make sure that we get as much meaningful, accurate, and consistent information as possible from the customer, to minimize resorting to default guidelines.

Figure 14. Add-on Equipment Data Collection Flow Chart[13]



For customers who are hesitant to answer, we will get approximate information by providing bracketed categories (e.g. “is it more or less than 10 years” … “is it more or less than 5 years”) and will incorporate any information we have available from the documentation or our own sources to help inform this value.

Summary

In the past, there was significant debate amongst the EAC on how we determined the length and nature of the EUL and RUL periods, particularly when the savings for one or more periods might have been zero.

For this reason, we have chosen to make explicit how we are going to ask about these issues, and collect the information necessary to reasonably quantify them. There will still be situations where we must follow

[13] Note that we add 2 years to the final equipment life question response because the equipment was installed in 2016 but we are asking about it in 2018.

default guidelines about items like RUL and whether equipment could be reused on new host equipment, though our proposed approach should reduce the number of times this is necessary.

Greenhouse baselines

For this round of CPSV, the evaluation team accepted most of the baseline assumptions used by the utilities, as applicable codes for commercial greenhouses do not provide specific guidance toward defining minimum efficiency levels for any of the equipment included in the utility programs. Further, Industry Standard Practice (ISP) for Ontario has not been studied. The baseline assumptions used by the utilities are generally closer to a “minimum available on the market” baseline rather than ISP. This approach is consistent with that used for the 2015 CPSV and NTG studies.

In accepting the program baseline for gross savings, the CPSV adjustment was likely to be small. However, a larger number of participants would likely say that they would have installed something significantly more efficient than the program baseline in the absence of the program, resulting in a NTG adjustment farther from 100%. If the evaluation team had used our experience of ISP in other jurisdictions as the baseline for gross savings, the CPSV adjustment was likely to be larger. However, more participants would be likely to say that they would have installed something that was the same as the ISP baseline, resulting in a NTG adjustment closer to 100%. Either way, the net savings would be similar.

Due to the number and size of these projects and the anticipated continued growth in greenhouse construction, we recommend scoping and undertaking a greenhouse baseline study in the future.

Union topics

Union specific topics that required significant decisions during the verification included evaluation approach to “influence factors,” and steam traps.

Influence factors

Previous CPSV efforts identified that Union was risking high free ridership on some project types including steam traps and steam leak repairs. The auditor recommended that Union discount savings to only claim the portion that they believe the program had influence on. Union implemented this recommendation by applying influence factors (the evaluation team’s term) to projects that reduced ex ante savings to account for anticipated partial free ridership. This reduced the incentives paid to customers as well. Union’s approach was conservative in that by reducing gross savings for these projects, a separate program-level NTG factor was also applied further reducing the claimed net savings.

The approach taken by Union demonstrated the utility’s concern with free ridership and represented a proactive way of addressing it.

In this evaluation, Union provided non-influence adjusted savings for the population of measures. This report used these non-influence corrected savings as both the ex ante savings for verified sites and as the total ex ante savings for the Union programs.

Steam traps

The CPSV team used a six (6) year EUL for these measures, consistent with 2015 CPSV. The reasoning in 2015, which we carried forward in 2016 is described below.

In previous project documentation, Union typically used seven (7) year EULs and Enbridge usually used six (6) year EULs. The CPSV team used a single EUL for both utilities, adopting a six (6) year EUL. The six-year value was based on a 2015 Massachusetts study and is also consistent with the California DEER database, Massachusetts evaluations and the Wisconsin Focus on Energy TRM. The Michigan MEMD (Michigan Efficient Measure Database) uses a five (5) year EUL.

Project documentation provided by Union to support a longer EUL for Union projects consisted of three reports from customers documenting their practices and survey results. Each of the three sites provided was a petrochemical plant.

The reports showed failure rates that could be consistent with 7, 11 and 13 years respectively.

Methodologically, 1/"failure rate" is a way to estimate the EUL, but it assumes that all traps fail randomly. Many factors affect the life to the steam trap: temperature, pressure, flowrate, operating hours, quality of the installation of the steam trap, location of the steam trap in the system (e.g., near elbows and constrictions, or in a straight line of pipe, or somewhere where near forklift traffic), presence of low concentrations of chemicals in the steam and more. The steam traps replaced as part of a program are going to be more likely to be those with a higher rate of failure than those of the facility as a whole.

DNV GL also reviewed the project files sent for the 2015 CSPV sample. While most of the project files do not report the number of traps surveyed, the evaluation team found two others in the 2015 project files that did (the two largest, one petrochemical and one other manufacturing). The failure rates in those sites were consistent with 4.3 and 8.1 years, but it was not clear how often they conduct surveys, so these could have been multi-year failures (longer implied EUL with a 1/"failure rate" method).

Five large customers are not necessarily representative of the program population, and the steam traps replaced by the program are likely to fail at a rate greater than those not replaced. The evaluation team does not have enough evidence to support a longer steam trap EUL for Union and used 6 years as the EUL, consistent with the current best available research (the Massachusetts study).[14]

Union uses three general approaches to calculating savings from steam traps. Most of the projects fall into approaches 1 and 2, with only a few projects using approach 3.

1. Standard: A calculation tool takes inputs provided by vendors and applies them to a simplified version of the Spirax Sarco equation, then applying a derating factor. Similar to the approach used by many vendors.
2. Chemical and Refinery: A calculation tool which uses four different equations depending on pressure and steam trap type, including choked and non-choked versions of both the Napier equation and ANSI standard equation. Generally applied to large chemical and refinery plants with thermodynamic traps.
3. Ad-Hoc: This approach represents a variety of methods which take different outputs which are likely to have been based on different assumptions from simple vendor calculations without specifically stating assumptions and converts steam loss to natural gas savings.

[14] Massachusetts 2013 Prescriptive Gas impact Evaluation. Prepared by DNVGL for Massachusetts Gas Program Administrators and Massachusetts Energy Advisory Council, June 2015.

For this round of evaluation, we accepted Union's methodology for Approaches 1 and 2, retaining their savings estimates unless we learned something from the site contact about the pressure, leak rate, or other condition that differed from the ex ante assumption/documentation. Where site information differed from the documentation, the methodology used to estimate ex post savings was determined on a case-by-case basis. For Approach 3, we planned to recalculate savings using a formula from the Illinois TRM, which generally produces savings estimates similar to the results from the Enbridge and Union Approach 1 methods. Approach 3 was in the end not used.

In the future, we propose that Union document and provide the orifice sizes used to check the vendor calculations. We also propose that Union provide all documentation, including charts, tables, and vendor documentation where needed, to evaluate Approach 2 sites. Union should also provide Excel calculators with live formulas rather than hardcoded values when the values were determined based on a formula or table as opposed to a chart or curve. If the chart or curve was the source, Union should provide a copy of the source material.

Some options for increasing the evaluation rigour for steam traps, might entail one or more of the following options:

- attempting to independently gather orifice sizes and maximum flow capacity charts by reaching out to vendors ourselves to develop a database which would allow us to independently verify calculations,
- purchasing a license for steam trap auditing software allowing for independent verification, or
- developing an assessment of measure life using DNV GL's ultrasonic leak detector to assess failure rate at participating sites.

Boiler Measure Lives

In the 2016 CPSV, we harmonized the boiler measure lives for the two utilities. Previously, Union used 20 years for boilers, while Enbridge used 25 years. DNV GL senior engineers were asked which was more reasonable and consensus was that 25 years is a reasonable estimate of measure life for most large boiler applications.

Enbridge topics

Enbridge specific topics that required significant decisions during the verification included evaluation approach to boilers and steam traps.

Boilers

For the 2016 evaluation of the Enbridge programs, the DNV GL team accepted the Etools calculation method along with the inputs used by Enbridge, except in cases where we were able to verify with site contacts a different condition than what was shown in the documentation. This approach is consistent with 2015.

For the future evaluations, the evaluation team will:

- look for more existing evidence from Enbridge (including emails from the customers, photographs, inspection reports, cut sheets, invoices, and conversation notes) to explain why site-specific inputs were used.

- request that Enbridge explicitly state for DHW boiler replacements in buildings with storage tanks whether the existing tank was replaced as part of the boiler replacement, and whether the existing tank was insulated.
- recommend that the DHW tank insulation be included as a separate measure from boiler replacement.
- consider additional research and reporting that includes:
  - pursuing a detailed review of the ASRAE 155P research,
  - pursuing a review of the Etools calculator which digs into the underlying assumptions and formulas, and
  - writing a detailed memo which summarizes the results of these reviews.

  One benefit would be greater clarity around the remaining calculation uncertainties and a better understanding of their effect. Another would be the identification of areas where the calculation rigor can be cost-effectively increased through further research.

During the evaluation, we noted that Enbridge's approach to boiler implementation appeared to take more of the boiler system into account than prescriptive and custom programs implemented elsewhere. This may be motivated by the savings estimation approach that Etools takes and provides justification for on average higher savings estimates from Etools than prescriptive boiler savings estimates elsewhere.

Due to the unique approach to market and calculation that Enbridge takes, future CPSV efforts should consider using an empirical measurement approach to directly estimate usage and/or savings for boilers. Empirical measurement could take the form of billing analysis or an on-site metering study which either measures natural gas directly or measures proxy values (such as flue gas temperature, water flow, or combustion fan electrical usage). On-site metering studies are becoming more cost effective as end-use natural gas metering expertise and the accuracy of meters to measure proxy variables continue to increase. An empirical sample-based study would not prevent Enbridge from using a custom calculation approach, but would help to calibrate the custom calculation and may provide value to the ASHRAE committee attempting to quantify seasonal efficiency. A billing analysis approach to estimate savings for multifamily and/or commercial boiler replacements may yield reasonable statistical significance due to the large numbers of boilers installed by Enbridge and the fact that boiler usage represents the large majority of gas usage in most buildings.

Steam traps

For this round of evaluation, consistent with 2015, the evaluation team accepted Enbridge's approach and savings estimates for steam trap evaluations unless we learned something from the site contact about the pressure, leak rate, or other condition that differed from the ex ante assumption/documentation. Where site contacts provided different information to the verifier than that included in the ex ante documentation, the approach used to estimate ex post savings was determined on a case by case basis (depending on what was different).

For their steam trap savings estimates, Enbridge uses an internal database of vendor-provided orifice sizes to check the calculations done by vendors. Based on a review of the formulas used by each vendor, calculations with a sample of pressures and leak rates used by each vendor, and a comparison to Spirax Sarco (whose calculation approach is generally recognized as superior by independent industry experts), Enbridge determines an vendor-specific average derating factor which is applied to the steam losses reported by each vendor. These derating factors are used to convert vendor savings estimates to ex ante program estimates.

The estimates that each contractor's approach produces can vary widely depending on orifice size, leak rate, pressure, and whether condensate is returned or not, so we deviated from Enbridge's method where applicable based on site-specific information.

The Enbridge estimates appear accurate for a group of projects averaged together. The evaluation checked these estimates using an alternative calculation method (based on the Illinois TRM approach) and achieved a similar total savings, though site specific estimates varied widely.

In the future, we will consider requesting that Enbridge document the orifice sizes they used to check the calculations done by vendor for the evaluated site and independently confirm the calculated savings. We will also consider increasing the rigour for steam traps which could entail one or more of the following options: attempting to independently gather orifice sizes by reaching out to vendors ourselves to develop a database, purchasing a license for steam trap auditing software, or assessing the measure life using DNV GL's ultrasonic leak detector to assess failure rate at participating sites.

APPENDIX C ADDITIONAL RESULTS

This appendix provides additional domain-level ratio results for the 2016 verification. The results in this appendix are not used in calculating verified gross savings, but are useful for better understanding the CPSV results. In the tables, results with less than 5 completes or absolute precision (+/-) greater than 20% are not shown. Large Volume ratios are not reported here, as Large Volume ratios were not assigned specific measure types.

Table 36: Cumulative gross savings realization rate for the Union Custom C&I program, by measure type

Measure Type	n		Ratio	90% Confidence Interval				Error Ratio	% Program Savings
	Measures	Sites		+/-	Lower Bound	Upper Bound	Relative Precision		
Greenhouse	12	8	100.41%	13%	87%	113%	13%	0.22	35%
Non-Process Heating	13	12	94.03%	11%	83%	105%	11%	0.22	23%
Other	17	16	102.42%	13%	90%	115%	12%	0.28	26%
Process and Process Heating	8	8	107.21%	13%	94%	121%	13%	0.19	16%

Table 37: Cumulative gross savings realization rate for the Union Custom C&I program, by sector and measure type

Sector	Measure Type	n		Ratio	90% Confidence Interval				Error Ratio	% Program Savings
		Measures	Sites		+/-	Lower Bound	Upper Bound	Relative Precision		
Agriculture	Greenhouse	12	8	100.41%	13%	87%	113%	13%	0.22	35%
	Other	6	5	99.06%	3%	96%	102%	3%	0.03	10%
Industrial	Non-Process Heating	7	6	88.51%	9%	80%	98%	10%	0.12	19%
	Process and Process Heating	6	6	107.66%	16%	92%	123%	14%	0.18	15%

Table 38: Cumulative gross savings realization rate for the Enbridge Custom C&I program, by measure type

Measure Type	n		Ratio	90% Confidence Interval				Error Ratio	% Program Savings
	Measures	Sites		+/-	Lower Bound	Upper Bound	Relative Precision		
Boilers	14	13	111.87%	9%	102%	121%	8%	0.18	26%
Heating Controls	11	10	95.36%	15%	80%	111%	16%	0.29	14%
Process	12	10	103.55%	9%	94%	113%	9%	0.17	36%

Table 39: Cumulative gross savings realization rate for the Enbridge Custom C&I program, by sector and measure type

Sector	Measure Type	n		Ratio	90% Confidence Interval				Error Ratio	% Program Savings
		Measures	Sites		+/-	Lower Bound	Upper Bound	Relative Precision		
Commercial	Boilers	6	5	106.40%	12%	94%	119%	12%	0.14	8%
Industrial	Process	12	10	103.55%	9%	94%	113%	9%	0.17	36%
MR MF	Boilers	8	8	115.10%	14%	101%	129%	12%	0.18	17%

APPENDIX D SAMPLE DESIGN

This section presents the stratification plan using the data provided by Union and Enbridge for 2016 custom C&I and multi-family projects.

Explore the Tracking Data

For both utilities, we describe a row in the tracking data as a “measure.” Enbridge’s tracking data has a clear project identifier that groups rows of measures into projects. Union’s tracking data does not have an project identifier that groups rows of measures together. Our review of Union’s data showed that there are sites that have multiple measures in a year, which is an indication that Union’s tracking data records are likely similar to a “measure” row in the Enbridge data in most cases.

Union CIMF

All savings in this section and throughout the Union CIMF sample design include influence correction factors as sampling was done prior to having non-influence corrected savings.

The Industrial segment of the Union CIMF program makes up more than three quarters of the savings in the program and more than half of the measures. Figure 15 and Table 40 provide an overview of the number of measures, average measure size and total CCM for each segment. In the figure and table, we can see that Agriculture makes more sense as a third segment for Union than MR MF based on number of measures and savings totals. Figures later in this section will include the Union MR MF projects in the Union Commercial segment.

Figure 15: High level view - Union CIMF Program

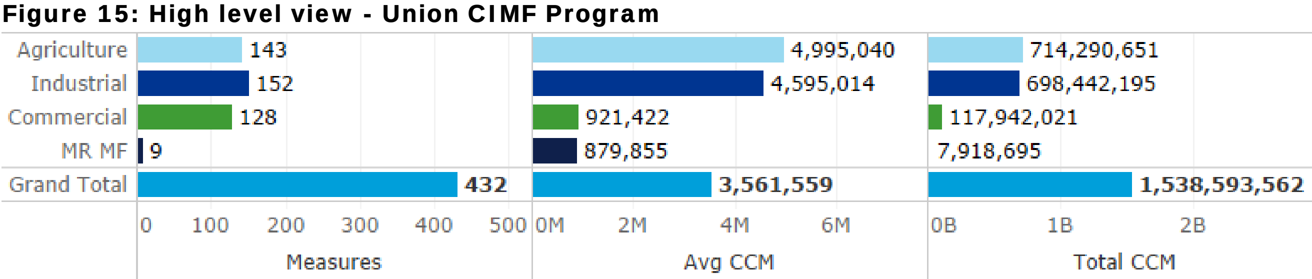


Table 40: High level view - Union CIMF Program

Segment	Measures	Average CCM per Measure	Total CCM
Agriculture	143	4,995,040	714,290,651
Industrial	152	4,595,014	698,442,195
Commercial	128	921,422	117,942,021
MR MF	9	879,855	7,918,695
Total Union CIMF	**432**	**11,391,331**	**1,538,593,562**

Distributions of the major measure types are shown in Figure 16 and Table 41. This figure shows that each segment has different dominant measure types that we hoped would have sufficient precision to report as separate domains. The table and figure include the MR MF measures and savings as part of the Commercial segment.

Figure 16: Potential reporting measure types - Union CIMF

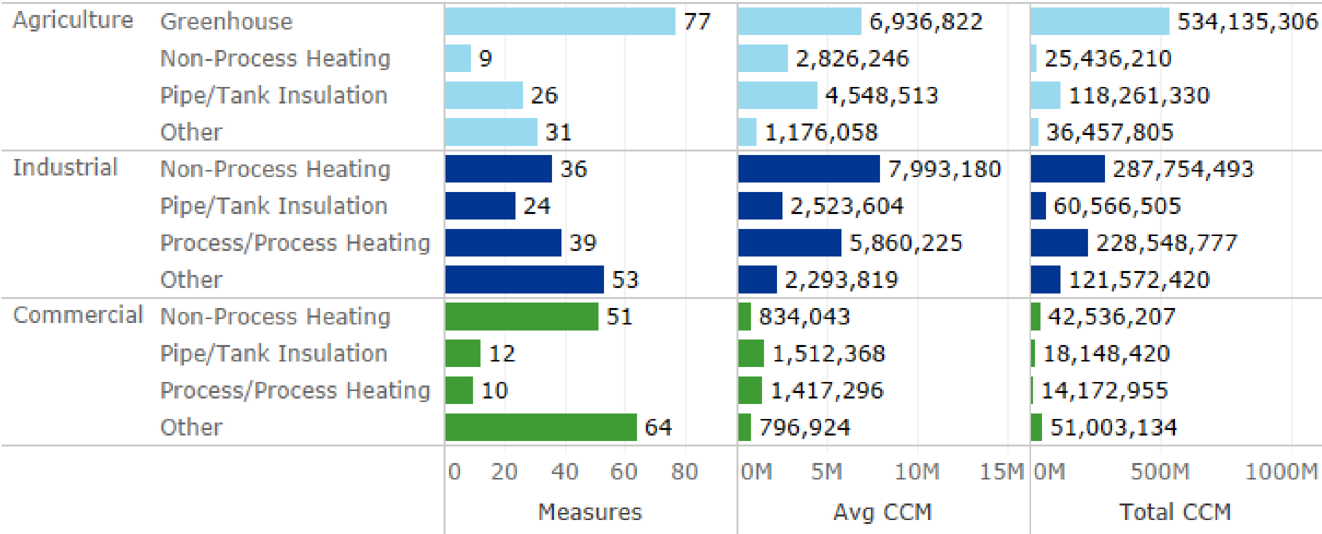


Table 41: Potential reporting measure types - Union CIMF

Segment	Potential Reporting Category	Measures	Average CCM per Measure	Total CCM
Agriculture	Greenhouse	77	6,936,822	534,135,306
	Non-Process Heating	9	2,826,246	25,436,210
	Pipe/Tank Insulation	26	4,548,513	118,261,330
	Other	31	1,176,058	36,457,805
Industrial	Non-Process Heating	36	7,993,180	287,754,493
	Pipe/Tank Insulation	24	2,523,604	60,566,505
	Process and Process Heating	39	5,860,225	228,548,777
	Other	53	2,293,819	121,572,420
Commercial and MR MF	Non-Process Heating	51	834,043	42,536,207
	Pipe/Tank Insulation	12	1,512,368	18,148,420
	Process and Process Heating	10	1,417,296	14,172,955
	Other	64	796,924	51,003,134
Total Union CIMF		**432**	**38,719,099**	**1,538,593,562**

Union Large Volume

All savings in this section and throughout the Union Large Volume sample design include influence correction factors as sampling was done prior to having non-influence corrected savings. Figure 17 and Table 42 provide an overview of the number of measures, average measure size and total CCM for each segment. The number of projects in Large Volume are low enough that it is unlikely we will be able to disaggregate into reporting categories after the analysis.

Figure 17: High level view - Union Large Volume Program

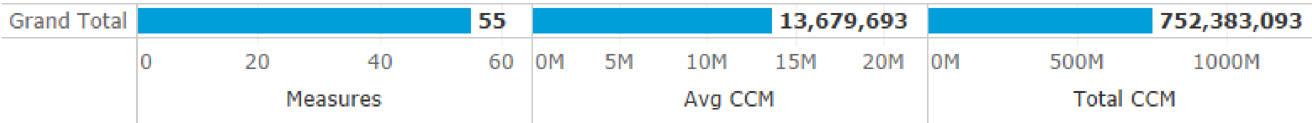


Table 42: High level view - Union Large Volume Program

Segment	Measures	Average CCM per Measure	Total CCM
Large Volume	55	13,679,693	752,383,093

Enbridge CIMF

The Industrial segment of the Enbridge CIMF program makes up more than half of the savings in the program and less than one quarter of the measures. Figure 18 and Table 43 provide an overview of the number of measures, average measure size in CCM and total CCM for each segment.

Figure 18: High level view of Enbridge CIMF Program

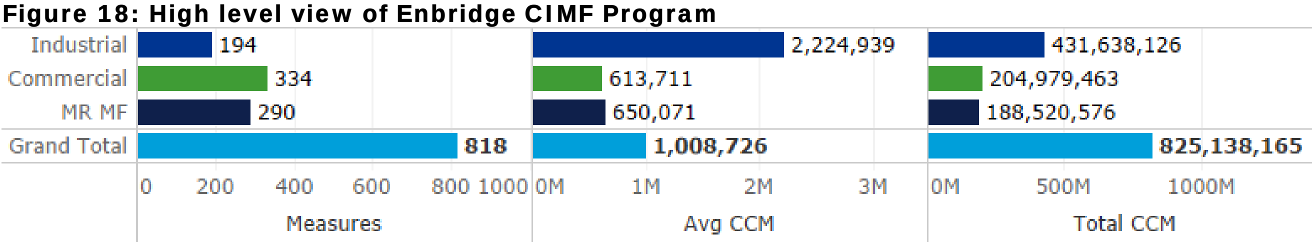


Table 43: High level view of Enbridge CIMF Program

Segment	Measures	Average CCM per Measure	Total CCM
Industrial	194	2,224,939	431,638,126
Commercial	334	613,711	204,979,463
MR MF	290	650,071	188,520,576
Total Enbridge CIMF	**818**	**1,008,726**	**825,138,165**

Distributions of the major measure types are shown in Figure 19 and Table 44. This figure shows that each segment has different dominant measure types that we hoped would have sufficient precision to report as separate domains.

Figure 19: Potential reporting measure types - Enbridge CIMF

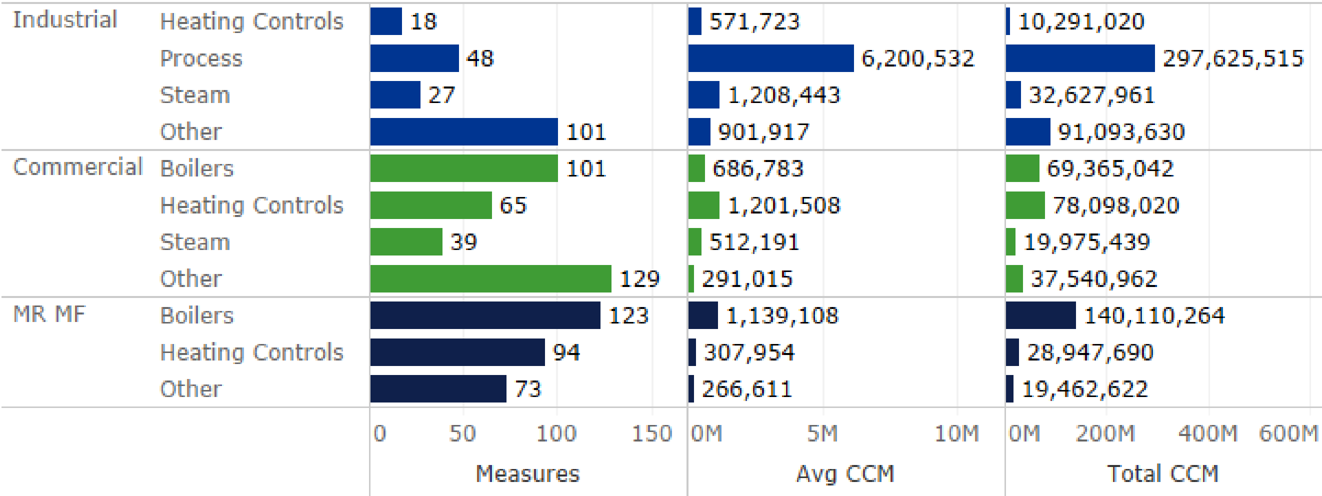


Table 44: Potential reporting measure types - Enbridge CIMF

Segment	Potential Reporting Category	Measures	Average CCM per Measure	Total CCM
Industrial	Heating Controls	18	571,723	10,291,020
	Process	48	6,200,532	297,625,515
	Steam	27	1,208,443	32,627,961
	Other	101	901,917.13	91,093,630
Commercial	Boilers	101	686,783	69,365,042
	Heating Controls	65	1,201,508	78,098,020
	Steam	39	512,191	19,975,439
	Other	129	291,015	37,540,962
MR MF	Boilers	123	1,139,108	140,110,264
	Heating Controls	94	307,954	28,947,690
	Other	73	266,611	19,462,622
Total Enbridge CIMF		**818**	**1,008,726**	**825,138,165**

Define the Unit of Analysis

In the 2015 CPSV/NTG study, the evaluation combined multiple similar measures for a customer into a single unit of analysis primarily as a way of reducing data collection burden during the NTG surveys. For 2016, NTG is not included in the project scope, so we did not employ the aggregation step and instead defined the unit of analysis as a row in the tracking data provided, which we defined as a measure.

Stratify the CPSV Data

For the 2016 gross savings verification effort, DNV GL stratified by:

- **Segment (Industrial vs. Commercial vs. Multifamily or Agriculture).** The 2015 gross savings verification found that there were differences in variability for the gross realization rates by segment, which is an indication that stratifying by segment should improve precision (relative to not using segment) for a given sample size. Segments were clearly defined in the tracking data[15] and the evaluation uses these definitions.

- **Measure size (CCM).** Within each segment, up to six size strata were assigned. The number of size strata within the categorical groupings were limited to ensure a minimum number of target completes per strata, with the exception of the largest strata which may only have one to three sites in the population for some groupings.

Preliminary samples were developed using two other stratification levels, each of which was employed to reduce budget risk for the evaluation. These categories were not ultimately used in the final sample design for this evaluation, but they will be used in setting the verification rigour and data collection method for sites. Our test of the sample design without the categories produced a sample and backup sample selection that sufficiently limits risk without stratification by these categories.

- **Rigour (Standard vs. High).** Stratifying by evaluation rigour level allows the evaluation to more accurately estimate costs based on the effort required to verify the measure. The preliminary rigour level for each measure was determined based on the complexity of calculation, the size of the individual measure and the proportion of program savings from measures of its type.

- **Data collection method (On-site vs. TSER).** Stratifying by data collection method also provides more evaluation cost certainty. For some measure types it is important for verification to view the measure on-site and observe specific aspects of operations, while for other measures a phone verification can adequately collect the necessary information to verify key inputs. The preliminary assignment of data collection method for each site was determined based on our judgement of the value of on-site verification relative to phone verification for the measure. All sites that were assigned high rigour were defaulted to on-site data collection as part of the rigour definition.

Stratification for the three programs are shown in Figure 20, Figure 21, and Figure 22 (Table 45, Table 46, and Table 47). The strata with the smallest measures are to the left (Sky Blue) with each stratum further to the right having progressively larger measures. Size is relative within each categorical grouping: for example, the largest measures in stratum 3 in the Union Commercial group may be (and in this case, are) smaller than those in stratum 2 for the Union Industrial group. Each stratum within a group has similar total

[15] Enbridge variable: “Market_Type” distinguishes all three segments; Union variable “Service Class (for Avoided Costs)” distinguishes Industrial and Commercial, while “building type” was used to separate multifamily from commercial.

savings amounts, except for the largest stratum, which often contains a small number of very large projects whose total savings are greater than the other strata for the segment. At the same time, smaller strata have more measures.

Figure 20: Stratification for Union CI&MF

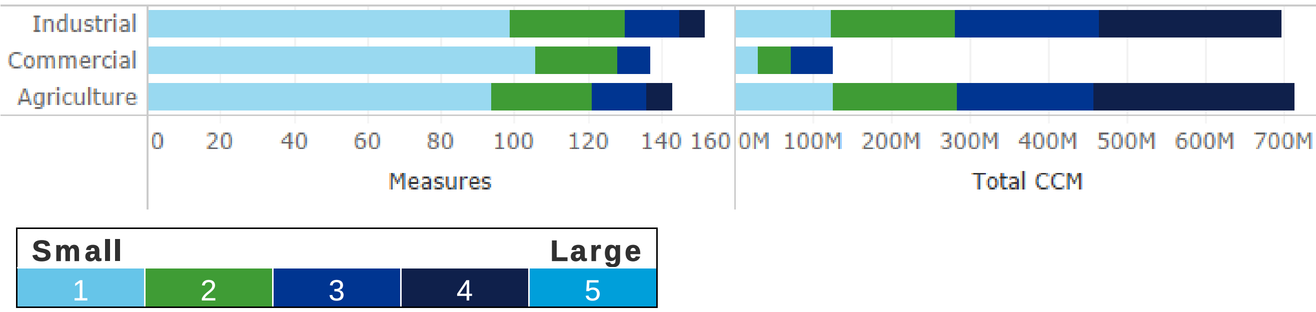


Table 45: Stratification for Union CI&MF

Segment	Size Stratum	Measures	Total CCM
Agriculture	1	94	125,520,095
	2	27	158,914,347
	3	15	174,558,203
	4	7	255,298,006
	5	0	0
Industrial	1	99	124,141,861
	2	31	157,704,435
	3	15	184,879,999
	4	7	231,715,900
	5	0	0
Commercial	1	106	29,769,001
	2	22	41,330,575
	3	9	54,761,140
	4	0	0
	5	0	0
Total Union CIMF		**432**	**1,538,593,562**

Figure 21: Stratification for Union Large Volume

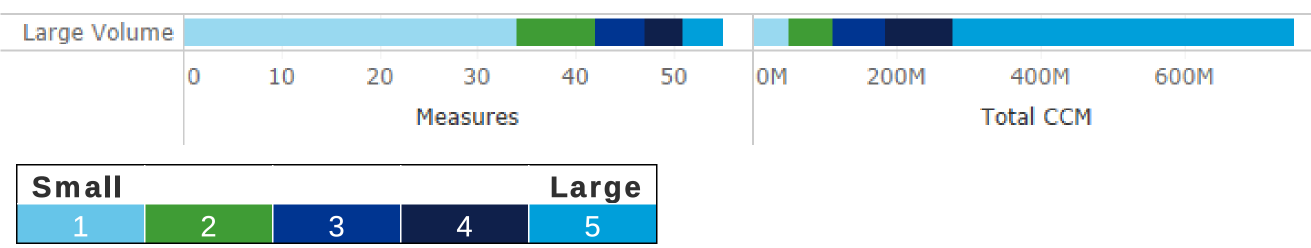


Table 46: Stratification for Union Large Volume

Segment	Size Stratum	Measures	Total CCM
Large Volume	1	34	50,827,042
	2	8	61,052,789
	3	5	72,082,797
	4	4	95,413,460
	5	4	473,007,005
Total Large Volume		**55**	**752,383,093**

Figure 22: Stratification for Enbridge CI&MF

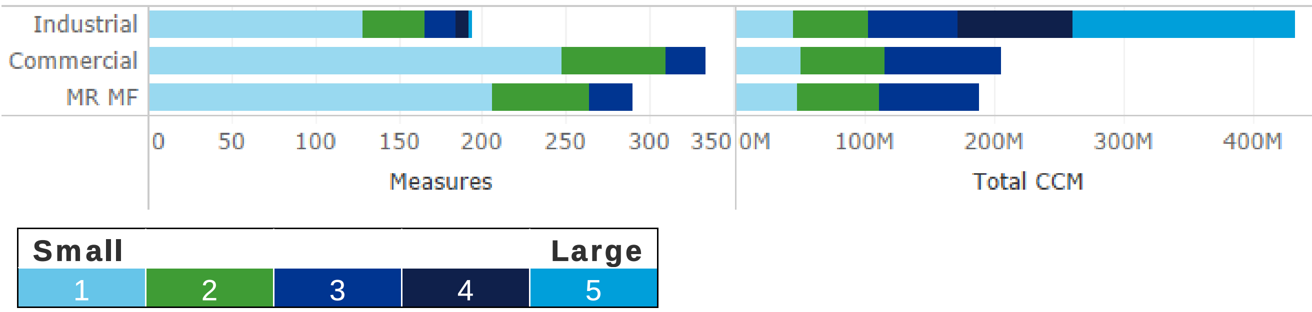


Table 47: Stratification for Enbridge CI&MF

Segment	Size Stratum	Measures	Total CCM
Industrial	1	129	45,359,137
	2	37	57,258,581
	3	18	68,495,230
	4	8	88,822,378
	5	2	171,702,800
Commercial	1	247	50,012,116
	2	63	65,850,731
	3	24	89,116,616
	4	0	0
	5	0	0
MR MF	1	206	48,048,524
	2	58	62,697,336
	3	26	77,774,716
	4	0	0
	5	0	0
Total Enbridge CIMF		**818**	**825,138,165**

Design the Samples

Table 48 shows the estimated error ratio (ER)[16] used in the sample design. The ER's used are based on an average of the 2015 CPSV results and 2015 assumption for complex measures (0.4). We further bounded

[16] Another term for error ratio is coefficient of variance (CV)

the ER, that is we would not use a ER less than 0.25 or greater than 0.60 in order to limit the risk of over or under collecting data. The upper bound was used on the Large Volume ER.

Table 48: Estimated error ratio used in sample designs

Utility	Program	Segment	ER
Enbridge	CI&MF	Industrial	0.26
		Commercial & MF	0.58
Union	CI&MF	Agriculture	0.33
		Industrial	0.33
		Commercial & MF	0.50
	Large Volume		0.60

The samples were designed to meet a 10% relative precision at 90% confidence threshold for each program. Table 49 shows the number of measures in the sample frame, the targeted sample size and the anticipated relative precision for each program. Figure 23, Figure 24, and Figure 25 (Table 50, Table 51, and Table 52) show the sample design for the programs. The figures show how the larger strata tend to have a higher sampling rate than the smaller strata. For example, for Enbridge Industrial, the largest stratum, #5 was sampled with certainty (all measures and savings are green), while the stratum with the smallest measures, #1 was sampled at a lower rate, (the majority of measures and savings in the stratum are sky blue). Measures within each stratum were selected randomly.

Table 49: Sample size and anticipated precision for each program

Utility	Program	Sample Frame (N)	Sample Size (n)	Anticipated Relative Precision @ 90% Confidence
Enbridge	CIMF	818	48	10%
Union	CIMF	432	44	10%
	Large Volume	55	18	9%

Figure 23: Sample Design – Union CIMF

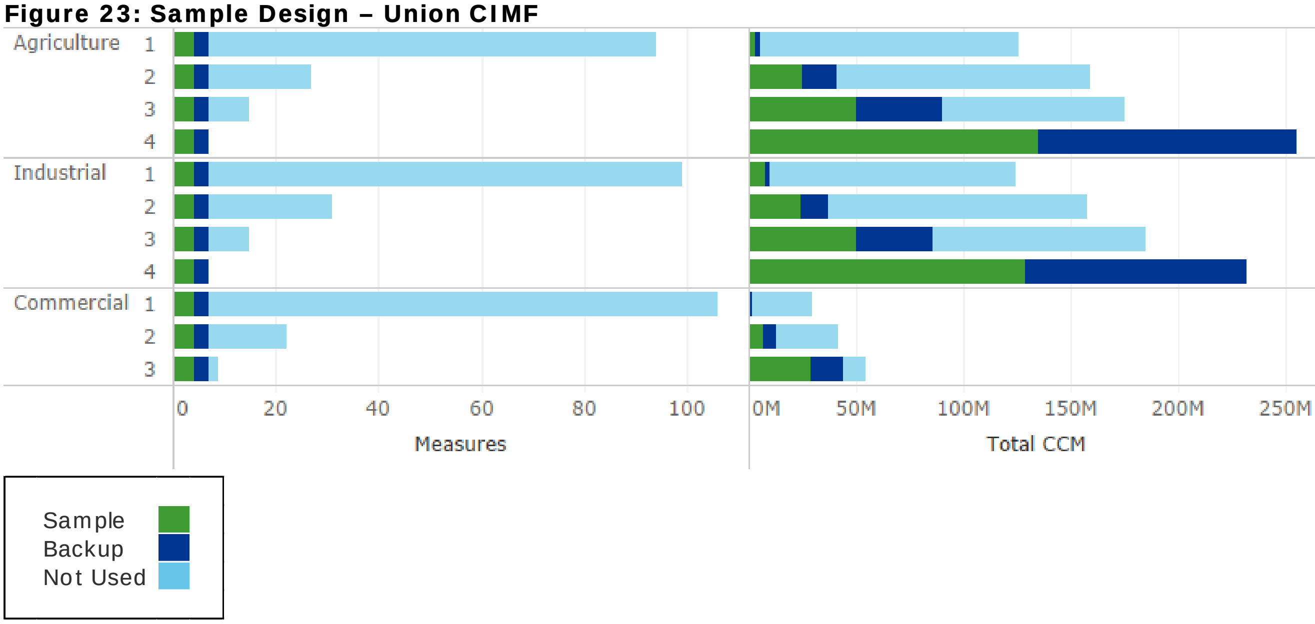


Table 50: Sample Design – Union CIMF

Segment	Stratum	Measures			Total CCM		
		Sample	Backup	Not Used	Sample	Backup	Not Used
Agriculture	1	4	3	87	3,138,035	2,194,205	120,187,855
	2	4	3	20	24,701,684	15,961,575	118,251,088
	3	4	3	8	49,965,990	40,081,372	84,510,841
	4	4	3	0	134,482,472	120,815,534	0
	5	0	0	0	0	0	0
Industrial	1	4	3	92	7,567,200	2,268,090	114,306,571
	2	4	3	24	24,048,780	13,157,365	120,498,290
	3	4	3	8	49,718,955	36,164,520	98,996,524
	4	4	3	0	128,636,380	103,079,520	0
	5	0	0	0	0	0	0
Commercial	1	4	3	99	663,370	581,480	28,524,151
	2	4	3	15	6,770,020	5,952,395	28,608,160
	3	4	3	2	28,933,420	14,670,580	11,157,140
	4	0	0	0	0	0	0
	5	0	0	0	0	0	0
Total Union CIMF		**44**	**33**	**355**	**458,626,306**	**354,926,636**	**725,040,620**

Figure 24: Sample Design – Union Large Volume

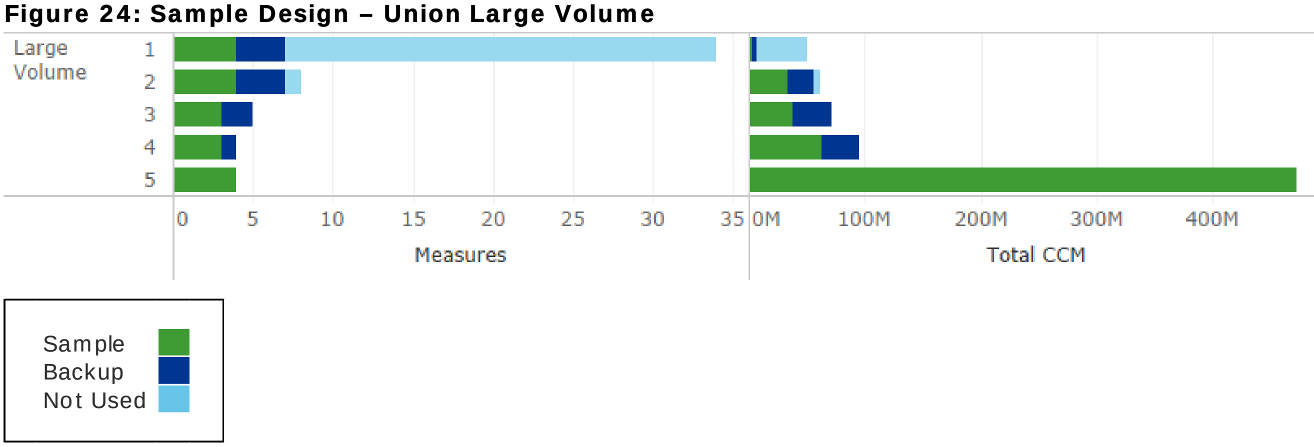


Table 51: Sample Design – Union Large Volume

Segment	Stratum	Measures			Total CCM		
		Sample	Backup	Not Used	Sample	Backup	Not Used
Large Volume	1	4	3	27	2,470,650	4,049,170	44,307,222
Large Volume	2	4	3	1	33,578,637	21,969,692	5,504,460
Large Volume	3	3	2	0	38,400,057	33,682,740	0
Large Volume	4	3	1	0	63,401,880	32,011,580	0
Large Volume	5	4	0	0	473,007,005	0	0
Total Large Volume		**18**	**9**	**28**	**610,858,229**	**91,713,182**	**49,811,682**

Figure 25: Sample Design – Enbridge CIMF

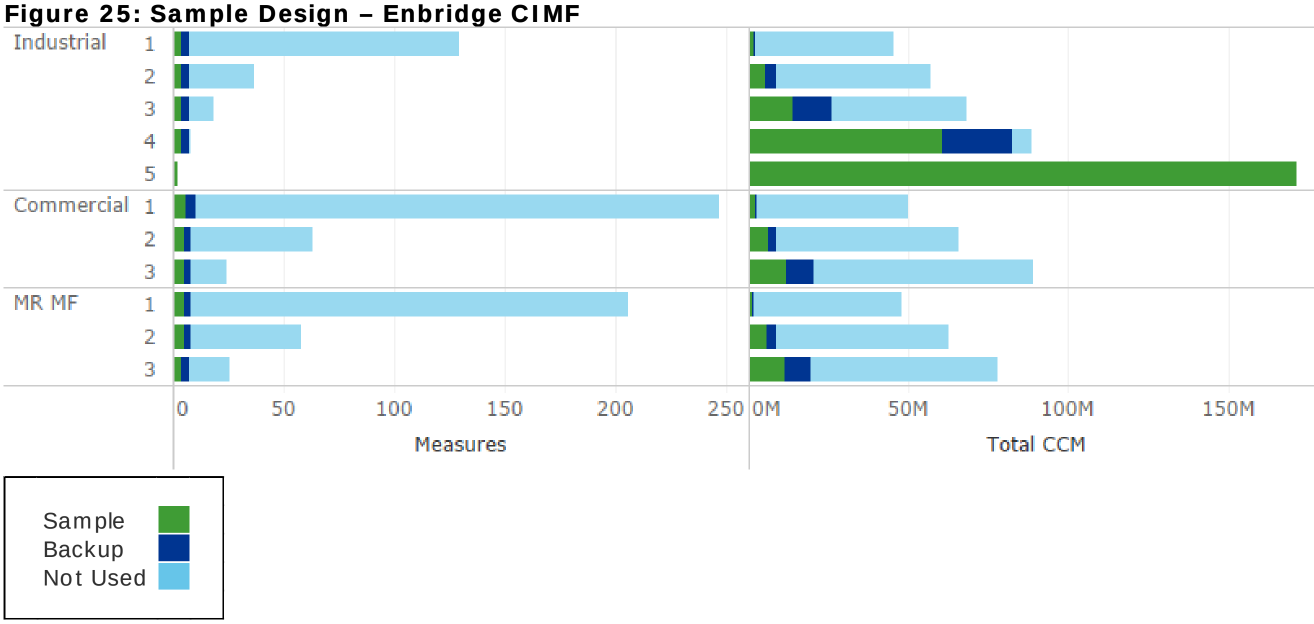


Table 52: Sample Design – Enbridge CIMF

Segment	Stratum	Measures			Total CCM		
		Sample	Backup	Not Used	Sample	Backup	Not Used
Industrial	1	4	3	122	1,718,210	565,197	43,075,730
	2	4	3	30	5,337,405	3,547,950	48,373,226
	3	4	3	11	13,787,335	12,140,840	42,567,055
	4	4	3	1	60,570,695	22,149,023	6,102,660
	5	2	0	0	171,702,800	0	0
Commercial	1	6	4	237	1,885,751	529,830	47,596,535
	2	5	3	55	5,987,410	2,569,850	57,293,471
	3	5	3	16	11,849,840	8,614,951	68,651,825
	4	0	0	0	0	0	0
	5	0	0	0	0	0	0
MR MF	1	5	3	198	922,195	671,025	46,455,304
	2	5	3	50	5,353,600	3,378,865	53,964,871
	3	4	3	19	11,215,147	8,084,875	58,474,694
	4	0	0	0	0	0	0
	5	0	0	0	0	0	0
Total Enbridge CIMF		**48**	**31**	**739**	**290,330,388**	**62,252,406**	**472,555,371**

Prepare the Sample and Backup Sample

We submitted a documentation request to the utilities when we delivered the final scope of work. For the 2016 CPSV sample, we requested documentation and contact information for 75% more measures than were in the primary sample (by stratum, rounded down to the nearest integer). The 75% additional constitutes the initial backup for the CPSV sample. This provided a small buffer beyond the minimum 60% response rate.

Backups for each sampled site/contact were only contacted if needed to meet the targeted number of completes.

Once we received the requested contact information, we identified instances where a contact was involved in multiple measures, even across sites. While the engineering reviews are conducted at the site level, the technical expert may have been involved in measures at multiple sites. Using this contact information and taking into account cross-site involvement, we assembled the sample frame. Table 53 shows the number of sample and backup measures for each program.

Table 53: Sample and backup sample totals by program

Utility	Program	Sample	Backup	Grand Total
Enbridge	**CIMF**	**48**	**31**	**79**
Union	CIMF	44	33	77
	Large Volume	18	9	27
	Union Total	**62**	**42**	**104**

Table 54 shows our anticipated completes by rigour and data collection method. The sample design did not have explicit targets for rigour or data collection method, so the final totals collected were expected to be different than what is shown in the table. Note that while rigour was specific to measure, sites selected for both TSER and on-site measures received an on-site.

Table 54: Sample totals by Program, Rigour and Data Collection Method

Utility	Program	Rigour - Data Collection Method	Measures	Sites*	Total Sample CCM
Enbridge	CIMF	High – On-site	12	9	247,585,630
		Standard – On-site	8	8	7,419,945
		Standard - TSER	28	27	35,324,813
Union	CIMF	High – On-site	18	18	345,975,616
		Standard – On-site	10	10	25,753,345
		Standard - TSER	16	16	86,897,345
	Large Volume	High – On-site	6	5	299,162,147
		Standard – On-site	12	8	311,696,082

*Because one site can have measures in different categories, the total sites reported in this table are greater than the total number of sites in the primary sample overall (referenced later): there are 94 sites in the primary sample, while the total in the site column of this table is 101.

APPENDIX E SAMPLE EXPANSION AND RATIO ESTIMATION

Sample Weights

This appendix describes how we calculate the sample weights for each stratum. In lay terms, the weight is simply the number of units in the sample frame (N) divided by the number of completed units in the sample (n). The interpretation of the weight is that each completed sample unit represents N/n units in the population (sample frame).

Notation:

N_x = number of units of analysis in stratum X

n_x = number of completed sample units of analysis in stratum X

The weight W_x is calculated as

$$W_x = N_x / n_x$$

We can understand the weight as meaning the response for one sampled unit in stratum X is representative of W_x units in the population. Table 55 shows a simple example. In the example, we completed 2 surveys with participants in the "North" and 10 surveys with participants in the "South." The weight for the "Northerners" is greater than that of the "Southerners," but because we completed more surveys with "Southerners" the combined weight of the "South" will be in proportion to its share of the population (both the population and sum of weights is 20).

Table 55: Example Sample Weights

Stratum Definition	Sample Frame (N)	Sample Completes (n)	Weight (W)	Interpretation
North	10	2	5 = 10/2	Each response represents 5 Northern participants
South	20	10	2 = 20/10	Each response represents 2 Southern participants

Without sample weights, the data collected from the "North" would be 17% (2/12) of the final result, while with weights, the "North" is 33% (10/30). The un-weighted result would be less accurate than the weighted result if the measured value differs along North/South lines. For example, if the "North" is more conservative than the "South" then political surveys without sample weights would end up with inaccurate results. If responding to surveys is negatively correlated with conservatism, then the weights help correct for the systemic bias in response rates.

The sample weight associated with an observation is consistent regardless of the segmentation of the data that we report by (reporting domains). This means that we can segment the data multiple ways in the report, with the final overall results consistent no matter the domain.

Special Cases

There are some special cases where the sample weight for a measure needs to be set to one (1) in order to use the data collected without biasing the result. Our sample designs target measures within a site and sample weights are developed at that level as well. When we collect data from a customer we will collect data on all of a customer’s sampled and primary backup measures in a single interview or site visit. This maximizes the data collected on each customer contact, without overburdening multi-measure customers, but can require special handling to ensure that extra data collected does not bias the sample. In this verification, all customers randomly selected into the sample and backup had contact attempted, so there were no instances where a measure was treated a special case for the reason described here.

Ratio Estimation

The calculation of the adjustment factors for tracking system gross savings uses appropriate case weights corresponding to the sampling rate as discussed above.

This evaluation will only produce new values for the gross realization rate (influence correction factors, engineering verification factors and gross realization rates) shown in this appendix. Net-to-gross ratios will be determined outside of the scope of this study. The NTG ratios are included in this appendix to provide the full picture of net savings calculation using ratio estimation.

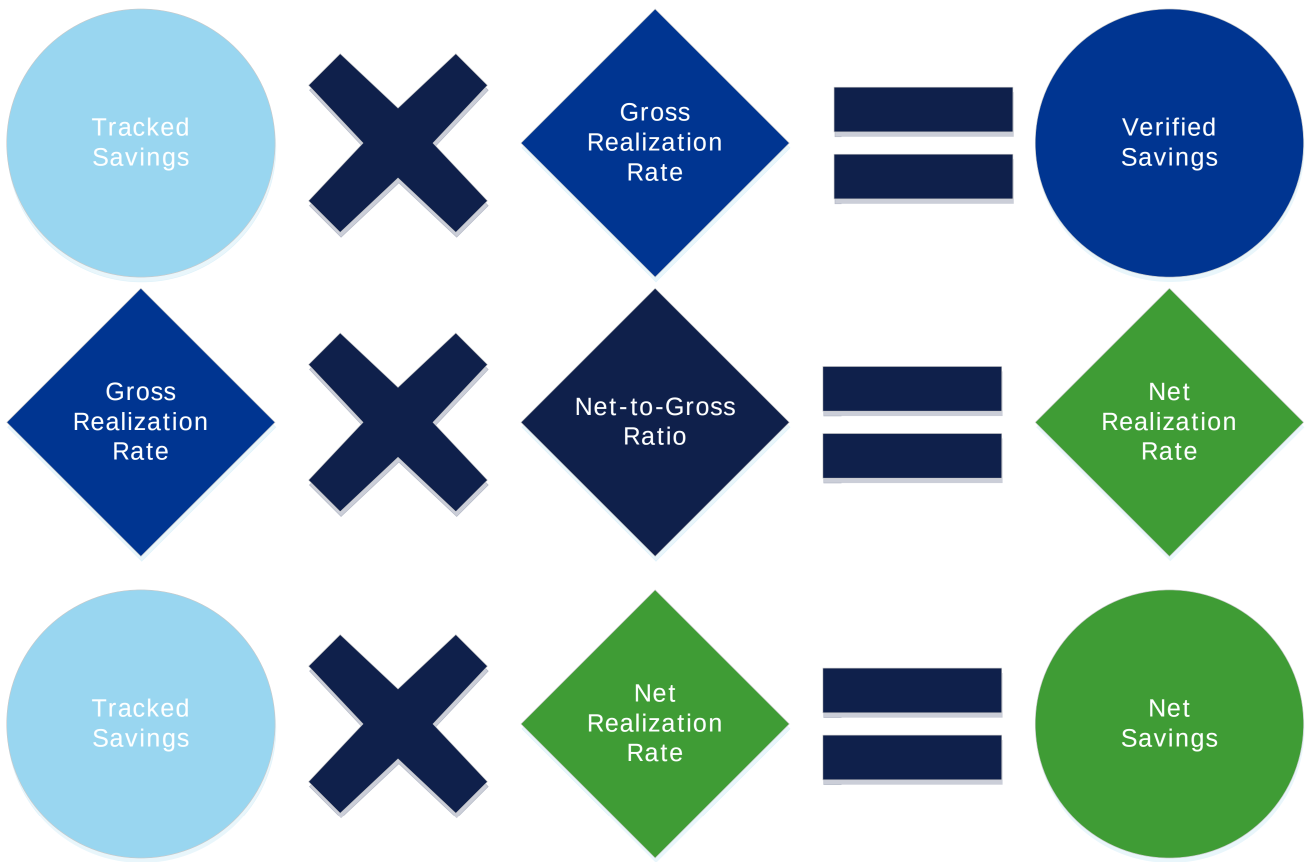
For an individual measure:

- The engineering verification factor is derived from the data collected during the participant survey data collection for TSER projects and through the on-site visits for other projects. Differences between the reported measure and the measure installed at the facility are accounted for here. The engineering adjustment factor is the ratio of the evaluator-verified savings to the program-reported savings.

The majority of the CPSV process involves determining the evaluator-verified savings estimate for each measure. The measure-level results are then combined using weights from the sample design to an overall adjustment factor.

Individual measure results are expanded to the estimate population savings (circles) using ratios (diamonds), as shown in Figure 26. Ratios are applied for each of the primary reporting domains and then summed to calculate the total for the program overall. For programs without an influence correction factor, the gross realization rate is calculated directly from the sample verified and tracked savings (as described below).

Figure 26: Ratios used to estimate verified and net savings



Two general ratio calculation approaches are employed: directly calculated and combined. The description of the process is easiest to understand through an example. The example below has three directly calculated adjustment factors: the installation rate, the engineering adjustment, and the net-to-gross factor. Each of these is calculated as a ratio estimator over the sample of interest (Cochran, 1977, p.165). The formulas for these factors are given below.

Notation: The following terms are used in calculating the adjustment factors:

G_{Tj} = tracking estimate of gross savings for measure *j*

G_{Ej} = engineer verified estimate of gross savings for measure *j*,

w_{Vj} = weighting factor for measure *j* used to expand the CPSV sample to the full population

V = number of measures in the CPSV sample

The gross realization rate is calculated directly:

$$R_V = \frac{\sum_{j=1}^{V} G_{Ej} w_j}{\sum_{j=1}^{V} G_{Tj} w_{Vj}}$$

Ratio Estimation Example

This section provides an example of the ratio estimation procedure. The results in this section are for explanatory purposes only.

The installed savings, and engineering verified savings, are calculated at the measure level and summed to the Measure Type level for each customer in the sample that completed a survey. Attribution is collected at the measure type level and is a function of the verified measure type savings for the customer. The sample weights are applied to the measure type level savings which is the unit of analysis. Table 56 shows the reported, installed and verified savings and NTG for Example Customer A's four measures reported in the program tracking database.

Table 56: Example Customer A in CPSV and NTG Sample

Measures	Measure Type	Reported m3	Installed m3	Verified m3	NTG
Space Heat Boiler 1	Space Heat	80,000	80,000	100,000	100%
Space Heat Boiler 2	Space Heat	56,000	56,000	55,000	
Process Heat	Process Heat	150,000	150,000	120,000	80%
Steam Trap Repair	Maintenance	12,000	12,000	14,000	20%

DNV GL engineers confirmed the customer installed all of the measures that were reported by the program; therefore, installed savings are equal to the reported savings. If a measure was initially reported as not installed, a second DNV GL engineer would contact the customer to verify this result. The engineering review produced adjustments to the installed savings for the first three of Customer A's reported measures, resulting in differences between the verified gross savings and installed savings for those measures.

The attribution rate is calculated for each measure type using the customer and supplier survey, if applicable, for Example Customer A using the methods that will be provided with the survey instruments. The measure type level attribution rates are then applied to the aggregated measure type level verified gross savings to estimate measure level net savings. Example Customer A received 100% attribution for the two space heat measures, 80% attribution for the process heat measure, and 20% attribution for the maintenance measure. Table 57 shows the verified gross and net savings for Example Customer A.

Table 57: Example Customer A Net Savings

Measure Type	Verified m3	NTG	Net m3
Space Heat	155,000	100%	155,000
Process Heat	120,000	80%	96,000
Maintenance	14,000	20%	2,800

Similar estimates are created for each customer in the sample. For this example, we assume Example Customers A to F comprise the Industrial Sector sample. Table 58 shows the un-weighted customer and commercial sector savings results.

Table 58: Example Industrial Sector Measure Type Level Sample

Customer	Measure Type	Reported m3	Installed m3	Verified m3	Net m3
A	Space Heat	136,000	136,000	155,000	155,000
A	Process Heat	150,000	150,000	120,000	96,000

A	Maintenance	12,000	12,000	14,000	2,800
B	Process Heat	250,000	250,000	180,000	180,000
B	Maintenance	20,000	20,000	14,000	0
C	Space Heat	150,000	150,000	140,000	35,000
D	Process Heat	80,000	80,000	81,000	81,000
E	Space Heat	70,000	70,000	70,000	0
F	Space Heat	14,000	14,000	13,000	0

Each customer in the sample frame is assigned to a sampling stratum as described in the sampling plan. Each customer in the sample is assigned a sampling weight based on the sample design and the number of completed sample points in each stratum. Assume that Example Customers A and C each have a space heat measure in a stratum that has four measures in the sample frame. The sampling weight for the space heat measures for Customers A and C is equal to the number of customers in the sample frame stratum divided by the number of stratum customers in the sample, or 4/2 = 2. The weighted savings for each customer is equal to the weight times the savings value. Table 59 shows the weights and savings (un-weighted and weighted) for each customer in the Example Industrial Sector if we assume the measure type weights shown.

Table 59: Example Industrial Sector Measure Type Level Weighted Savings

			Reported m3		Installed m3		Verified m3		Net m3	
Customer	Measure Type	Weight	unweighted	weighted	unweighted	weighted	unweighted	weighted	unweighted	weighted
A	Space Heat	2	136,000	272,000	136,000	272,000	155,000	310,000	155,000	310,000
A	Process Heat	3.5	150,000	525,000	150,000	525,000	120,000	420,000	96,000	336,000
A	Maintenance	20	12,000	240,000	12,000	240,000	14,000	280,000	2,800	56,000
B	Process Heat	1	250,000	250,000	250,000	250,000	180,000	180,000	180,000	180,000
B	Maintenance	18	20,000	360,000	20,000	360,000	14,000	252,000	0	0
C	Space Heat	2	150,000	300,000	150,000	300,000	140,000	280,000	35,000	70,000
D	Process Heat	3.5	80,000	280,000	80,000	280,000	81,000	283,500	81,000	283,500
E	Space Heat	15	70,000	1,050,000	70,000	1,050,000	70,000	1,050,000	0	0
F	Space Heat	25	14,000	350,000	14,000	350,000	13,000	325,000	0	0

The next step is to determine program overall adjustment factors. For kWh the Industrial Sector the installation rate, engineering verification factor, and attribution adjustment factor are:

3,627,000 weighted installed m^3 / 3,627,000 weighted reported m^3 = 100% installation rate

3,380,500 weighted verified gross m^3 / 3,627,000 weighted installed m^3= 93.2% eng. verification factor

1,235,500 weighted net m^3 / 3,380,500 weighted verified gross m^3 = 36.5% attribution adjustment.

The verified gross realization rate (RR) is the product of the installation rate and the engineering verification factor, or 100% times 93.2% = 93.2% for this example. The net RR is the product of the verified gross RR and the attribution adjustment, or 93.2% times 36.5% = 34% for this example.

The same principle can be applied to each Measure Type to get the Measure Type level adjustment factors. With the unit of analysis remaining the same (at the measure type level), the same process can be used to produce adjustment factors for any domain that we are able to define for the whole sample.

Applying Ratios to Domains

Ration application refers to multiplying the gross RR and net RR times the program tracking savings to produce the total verified and net savings results for a program.

The general formula for total verified gross savings is:

The general formula for total net savings is:

The body of the report discusses how to calculate the population adjustment factors, which are based on a finite, fixed distribution of projects. You can also calculate for subsets, called domains. Viewing domain-level results allows for insights into program performance that can lead to program improvements. Domain-level ratios can also be used to apply ratios and calculate overall program savings totals. The ratio results will be generated for each of the domains of interest (subsets of the population that stakeholders agree are important) and overall for each of the utilities' programs.

The level at which one applies the ratios has an effect on the overall verified and net savings estimate for each program. There are two basic approaches that we take. The first is to apply the overall program ratio. This is appropriate to retrospective evaluation where the population that the applied ratio is the same as the population of study and is static.

The second is to apply the ratio at the domain level. This is appropriate for all uses and recommended for estimating savings for programs or program years that are not the same as the population of study. Another approach is to apply the ratio at the stratum level. This is really a subset of the domain application approach where the domain used is the sample strata.

We recommend applying ratios by domains in most cases in order to improve accuracy. Assuming a sufficient sample size in each domain, domain-level precisions are usually sufficient for the approach. While 90/10 relative precision is typically the threshold targeted for an overall result, precisions usually have lower threshold for domain-level application as the resulting precision of the overall result will be better than the component parts.

If one domain has an extreme adjustment, the accuracy of the overall result is improved if domain level ratios are applied to the domain level savings. Table 60 shows an example where we apply the gross RR and net RR directly and by domains. The sample weighted savings in the example closely match the population savings: one domain, process heat, is 3.2% different, while the other domains are each within 3% and overall the difference is less than 1%. The ratios and resulting savings are also similar, within one percent of one another. Though the results in the example are similar, the final net savings are more accurate when calculated by domains. In the example, both space heat and maintenance measures had very different attributions from process heat and each were slightly over-represented in the weighted sample savings, which resulted in lower net savings when we applied the overall ratio directly.

Table 60: Example of Ratios Applied Overall vs. by Domains

	A	B	C	D		
Measure Type	Population m3	Sample Weighted m3	Gross RR	Net RR	Verified Gross Savings (A*C)	Net Savings (A*D)
Space Heat	1,950,000	1,972,000	99.6%	19.3%	1,943,078	375,761
Process Heat	1,090,000	1,055,000	83.7%	75.8%	912,810	826,024
Maintenance	585,000	600,000	88.7%	9.3%	518,700	54,600
Overall - Ratios Applied Directly	3,625,000	3,627,000	93.2%	34.1%	3,378,636	1,234,819
Overall - Ratios Applied by Domains and Summed	3,625,000		93.1%	34.7%	3,374,589	1,256,384
Difference			0.1%	-0.6%	4,047	-21,566

Neither applying the overall ratio directly nor by domains has an inherent systemic bias, but when the differences among the domain ratios are significant, applying by domains results in improved accuracy.

The choice between how to apply the ratios does not affect whether or which domains are reported. There is a large inherent value in looking at program results by multiple domains in order to better understand where the program is doing well and what areas have room for improvement.

Criteria for selecting domains for reporting and application

DNV GL will select the domains that are reported and those that will be applied to estimate gross savings for the programs.

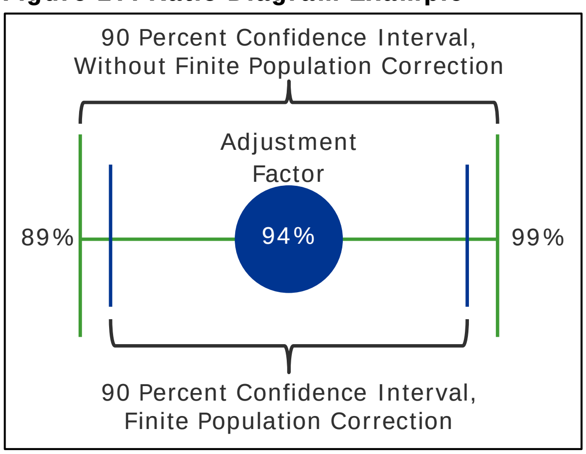
Table 61: Relevant statistics.

Term	Definition
Ratio/Adjustment factor	A point estimate of the evaluation findings expressed as a percent.
+/- or Absolute Precision	If the evaluation were repeated several times selecting samples from the same population, 90%[17] of the time the ratio would be within this range of the ratio
Confidence interval	The upper bound is defined by the ratio plus the absolute precision. the lower bound is defined by the ratio minus the absolute precision.
Relative Precision	The relative precision is calculated as the absolute precision divided by the ratio itself. By convention, relative precisions are the statistic that are targeted in sampling (ie. 90/10 is a relative precision metric)
Finite population correction (FPC)	FPC is a factor that reduces the measured error of samples drawn from small populations (less than 300). FPC applies when the ratio is applied to the same population from which the sample was drawn.

Figure 27 shows an example:

- the adjustment factor (ratio) as a blue point
- the 90% confidence interval *with finite population correction* (blue)
- the 90% confidence interval *without finite population correction* (green)

Figure 27: Ratio Diagram Example



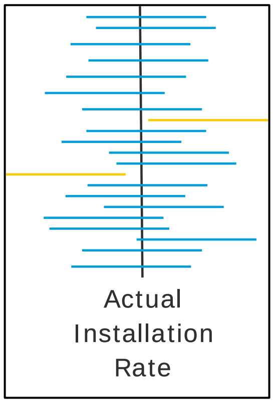
The plus/minus (±) error (%) indicated at the 90% confidence interval is the absolute difference between the estimated percentage and the upper or lower confidence bound. For example, in Figure 27, the ratio is 94% and the non-FPC 90% confidence interval is ± 5 percentage points (i.e., 94% ± 5%).[18] Another way of saying this is that there is a 90% probability that the actual ratio for the next year's program lies between 89 and 99 percent. Figure 28 demonstrates this concept by showing twenty hypothetical confidence intervals

[17] 90% is the confidence limit that we are using.

[18] The critical value for calculating the confidence interval ± for each adjustment factor is determined using Student's t-distribution and n-1 for the degrees of freedom, where n is the sample size. For 2-tailed estimates (ratios that could be above or below 100%) the appropriate t-stat used to calculate precision from the standard error is close to 1.645.

calculated from twenty different samples of the same population. Eighteen out of twenty (90 percent) include the true population ratio.

Figure 28: Ninety Percent Confidence Interval



Note: Each horizontal line represents a confidence interval. Yellow confidence intervals do not include the actual ratio.

The relative precision of the ratio is calculated as 5%/94% =5.3%.

For low ratios, relative precisions may be quite high, even when the confidence interval around the ratio is quite narrow. Consider a ratio of 40% with the same 5% absolute precision as in the above example. While the absolute precisions are the same, the latter ratio (40%) has a relative precision of 5%/40% =12.5%.

Because relative precisions can over-represent error for low ratios (and under-represent errors for ratios above 100%), we prefer to set thresholds for reporting and application based on the absolute precision rather than the relative precision. Where prospective application (applying the results of a study to a different program year than the one studied) is used, FPC-off errors are appropriate and the thresholds for reporting and application may be relaxed somewhat depending context and needs.

For determining which ratios to report and apply we use the following rules:

- The minimum sample size for a reporting or application domain will be five.
- The absolute precision threshold for reporting ratio for a domain will be +/- 20% at 90% confidence with FPC-on.
- The absolute precision threshold for applying ratio for a domain will be +/- 15% at 90% confidence with FPC-on for retrospective application.
- The absolute precision threshold for applying ratio for a domain will be +/- 20% at 90% confidence with FPC-off for prospective application.

Reporting domains are defined as combinations of categorizations where sample sizes and precisions allow:

- Stratification segments
- Measure types

APPENDIX F SITE LEVEL SAVINGS RESULTS

This appendix provides the verification results for each measure in the sample. For each measure the utility's tracking savings, the verification's verified savings and the realization rate are provided.

Table 62: Site level verification results – Union Custom C&I program

Segment	Measure Type	Measure ID	Utility Tracking CCM	Verified CCM	Realization Rate
Union - CIMF - Agriculture	Greenhouse	UO020-2	48,641,530	54,170,404	111%
		UO012-2	39,116,392	30,148,954	77%
		UO012-1	37,120,678	31,173,952	84%
		UO020-6	27,514,312	29,680,700	108%
		UT051-1	18,201,392	21,464,750	118%
		UT115	11,535,030	8,200,690	71%
		UO020-1	11,149,240	17,449,695	157%
		UO079-2	10,966,780	15,542,020	142%
		UO020-3	7,390,480	7,271,460	98%
		UO032	4,512,144	2,311,654	51%
		UO033	4,329,255	4,382,340	101%
		UO147	892,280	1,022,400	115%
	Other	UT051-2	10,913,200	10,041,060	92%
		UO012-3	8,666,800	8,566,000	99%
		UT053	5,820,460	5,765,480	99%
		UO020-4	2,397,780	2,397,780	100%
		UO079-1	252,840	331,410	131%
		UO020-5	99,915	79,515	80%
Union - CIMF - Commercial	Non-Process Heating	UO057	3,605,900	3,605,900	100%
		UT151	2,916,600	2,433,840	83%
		UT106	937,760	889,304	95%
		UO005	384,100	1,015,300	264%
		UT075	147,270	147,270	100%
		UT111	37,350	37,350	100%
	Process and Process Heating	UO039	4,474,080	4,474,080	100%
		UO127	875,060	910,200	104%
	Other	UO087	13,708,800	15,024,760	110%
		UO114	6,449,960	4,804,200	74%
		UT103	873,760	873,760	100%
		UO145	36,850	55,275	150%

Segment	Measure Type	Measure ID	Utility Tracking CCM	Verified CCM	Realization Rate
Union - CIMF - Industrial	Non-Process Heating	UO049-1	58,686,760	58,686,760	100%
		UO049-2	42,614,540	42,614,540	100%
		UO077	31,693,720	12,835,564	40%
		UO144	28,771,260	15,436,580	54%
		UT080	12,798,940	12,798,940	100%
		UO036	6,453,285	6,453,285	100%
		UT101	3,443,140	3,974,680	115%
	Process and Process Heating	UO141	26,169,600	26,169,600	100%
		UO137	19,511,260	14,722,040	75%
		UO093	11,889,480	13,029,700	110%
		UO040	2,848,400	2,697,040	95%
		UO105	1,704,280	2,093,160	123%
		UO064	289,080	867,240	300%
	Other	UT058	13,852,635	9,512,174	69%
		UO037	11,177,900	19,539,280	175%
		UT082	6,555,260	6,555,260	100%
		UO109	4,801,820	4,801,820	100%
		UT094	3,611,900	3,611,900	100%
		UT150	3,072,300	3,072,300	100%
		UT059	1,357,420	1,266,920	93%

Table 63: Site level verification results – Union Custom Large Volume program

Segment	Measure Type	Measure ID	Utility Tracking CCM	Verified CCM	Realization Rate
Union - Large Volume - Large Volume	All Large Volume	UO136	229,432,213	266,008,380	116%
		UO140-1	97,092,525	57,515,840	59%
		UO066-3	53,352,644	53,352,640	100%
		UO066-2	35,568,422	35,568,420	100%
		UO140-2	34,375,067	33,420,220	97%
		UO008	24,232,533	28,095,700	116%
		UO142	23,280,720	25,305,140	109%
		UO135-1	19,446,180	16,090,040	83%
		UO028-2	13,279,995	23,171,265	174%
		UO066-1	12,896,750	12,801,500	99%
		UO135-2	12,223,312	10,113,744	83%
		UO028-1	11,432,750	12,061,200	105%
		UO131-1	8,420,000	5,927,680	70%
		UO131-3	6,868,070	6,858,000	100%
		UO007-1	6,857,817	6,857,817	100%
		UO135-4	5,113,890	4,336,345	85%
		UO045	1,222,154	1,368,265	112%
		UO131-2	834,732	834,732	100%
		UO135-3	93,490	93,489	100%
		UO007-2	85,643	427,720	499%

Table 64: Site level verification results – Enbridge Custom C&I program

Segment	Measure Type	Measure ID	Utility Tracking CCM	Verified CCM	Realization Rate
Enbridge - CIMF - Commercial	Boilers	ET133-2	1,659,275	1,659,275	100%
		ET006	1,036,375	1,407,000	136%
		ET034	925,450	925,450	100%
		ET047	362,100	362,100	100%
		ET054	349,700	349,700	100%
		ET133-1	61,700	61,700	100%
	Heating Controls	EO097	4,227,660	4,269,930	101%
		EO048	3,028,920	3,391,200	112%
		ET071	2,409,525	2,409,525	100%
		ET112	2,320,620	1,308,150	56%
		EO011	288,195	139,050	48%
		EO001	108,190	87,240	81%
	Steam	ET044	619,416	619,416	100%
	Other	ET134	2,095,350	1,162,350	55%
		ET072	952,755	670,275	70%
		ET046	815,505	1,324,890	162%
		ET120	23,760	9,105	38%
Enbridge - CIMF - Industrial	Process	EO025	87,174,420	103,422,320	119%
		EO089	84,528,380	99,392,000	118%
		EO102	18,882,380	26,735,080	142%
		EO017-3	11,536,320	17,586,040	152%
		EO013-1	11,347,200	9,219,600	81%
		EO042	7,336,260	11,946,580	163%
		EO010-1	4,718,820	511,547	11%
		EO073	4,495,080	1,432,320	32%
		EO017-1	4,389,680	4,285,640	98%
		EO017-2	3,769,170	3,696,880	98%
		EO019	1,558,420	526,720	34%
		EO121	1,293,740	326,020	25%
	Steam	ET129	341,706	88,032	26%
		ET015	155,526	168,480	108%
	Other	EO013-2	18,804,795	55,850,860	297%
		EO010-2	2,745,160	349,112	13%
		ET125	1,228,995	1,079,145	88%
		ET061	1,067,445	1,067,445	100%
		EO041	920,100	1,219,440	133%
		ET030	707,675	707,475	100%

Segment	Measure Type	Measure ID	Utility Tracking CCM	Verified CCM	Realization Rate
Enbridge - CIMF - MR MF	Boilers	ET038	3,875,850	3,882,469	100%
		ET148	3,595,850	3,602,596	100%
		ET074	1,957,547	1,619,094	83%
		ET123	1,785,900	1,975,150	111%
		ET128	1,112,350	1,112,350	100%
		ET018	963,985	1,665,150	173%
		ET069	853,425	1,208,850	142%
		EO100-2	484,625	696,765	144%
	Heating Controls	EO078-2	712,170	852,945	120%
		EO149	208,920	181,710	87%
		EO055	189,225	168,195	89%
		EO022	141,285	254,820	180%
		EO078-1	39,180	51,585	132%
	Other	ET016	1,716,795	1,480,140	86%
		EO100-1	67,880	91,780	135%

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