Final Interim Report

2009 Cross-Cutting Evaluation of C&I

Funded By:

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1 INTRODUCTION

OPA'S EXISTING C&I PROGRAMS

Research Into Action and its contractors, Nexant, Dennis Landwehr Engineering, and Harris/Decima, are conducting a Cross-Cutting Evaluation of the Commercial and Institutional Retrofit Incentive Initiative (C&I Initiative), sponsored by the Ontario Power Authority (OPA). The C&I Initiative is a suite of key electricity conservation programs designed to assist the province achieve its 1,350 MW savings target by 2010.

The C&I Initiative offers program participants financial incentives to reduce the incremental costs of installing energy efficient equipment on existing commercial and institutional buildings, including commercial office buildings, retail stores, hotels, agribusiness and the municipal, academic, social and health care sectors.

The C&I Initiative is delivered by four program streams throughout Ontario, which differ in terms of goals, geography and/or target customer groups. Each stream consists of projects that vary in scope and size (i.e., load reductions, floor space, number of measures, etc.) and the complexity of project-level measurement & verification (M&V) processes.

The four streams are:

- ➡ Building Owners and Managers Association (BOMA) Toronto Conservation and Demand Management (CDM) Program [City of Toronto]
- ➡ City of Toronto Better Buildings Partnership Program for Existing Buildings (BBP-EB) [City of Toronto]
- ➡ Toronto Hydro Business Incentive Program (BIP) [City of Toronto]
- ➡ Electricity Retrofit Incentives Program (ERIP) delivered by local distribution companies (LDCs) [all of Ontario, except Toronto]

The C&I Initiative has both prescriptive and custom streams based around broad categories of energy efficiency measures. The eligible measures include, but are not limited to, lighting, heating, ventilation & air conditioning (HVAC) and electric motors.

Number of participants and reported 2009 savings are shown in Table 1.

Table 1: Number of Participants and Reported Savings in 2009

PROGRAM	NUMBER OF PARTICIPANTS	REPORTED KW SAVINGS	REPORTED MWH SAVINGS
BBP	104	6,804	28,498
BIP	79	3,511	N/A
BOMA	80	3,630	20,430
ERIP	1,294	31,213	N/A
Total	**1,557**	**45,208**	**48,928**

EVALUATION GOALS AND OBJECTIVES

The goals and objectives of the 2009-2010 impact evaluation are to:

- Verify gross energy and demand savings based on an engineering study at a high degree of confidence (90/10 overall) and by program delivery streams, project type, and measure type
- Conduct an attribution study to calculate net energy and demand savings
- Follow-up and assess the implementation of 2008 program evaluation recommendations and identify opportunities for any further program improvements
- Review and compare key program elements and delivery/results across all four PDAs and a sample of LDCs, as well as business or property types
- Conduct cost-effectiveness analyses
- Review prescriptive input assumptions

2009 Interim Reporting Objectives

The goals and objectives of the 2009-2010 impact evaluation are to:

- Verify the 2009 gross energy and demand savings with a high degree of confidence (90/10 overall) and by program delivery streams, project type, and measure type.
- Calculate Net-to-Gross (NTG) ratios and net energy and demand savings.
- Review prescriptive input assumptions for measures encountered during the 2009 impact evaluation.
- Conduct cost-effectiveness analyses of the 2009 projects.

2 VERIFIED ENERGY AND DEMAND SAVINGS

METHODOLOGY

The process to verify the program energy and demand savings consists of the following steps:

- Obtain records
- Sampling
- File review
- On-site inspections
- Engineering Calculations

Obtain Records

A significant part of the effort in the impact evaluation was obtaining records. Three types of data were collected: program tracking records, project files, and records from sources other than program staff.

The program tracking records were electronic data sheets summarizing project specifics for each program, including customer name, site address, savings reported, geographic location, incentives paid, etc. OPA's 2009 tracking databases were obtained for each of the four programs as well as the databases BOMA and BBP staff use to track their programs. BIP staff reviewed OPA's BIP 2009 tracking database and confirmed that the list of projects was correct. These databases were used to develop the sample used to conduct our impact evaluation. We received an updated ERIP database in June 2010, which included projects that had been added to the population since the previously received ERIP database.

Project files are the records the programs maintain for each project and include the application documents, savings calculations, any additional documentation on the history of the project. This information is required to conduct a credible review of projects. Project files were obtained from the OPA and program implementers. The quality of the records varied between projects within each program. Some examples of significant variation include the existence and level of detail included in any equipment inventories and whether detailed savings calculations were included in the project file. Also, project document revisions to projects were not uniformly included in project files.

During the site inspections for the impact evaluation, it was found that there were numerous cases where additional information about the projects was held either by the customer, the contractor implementing the project, or the third party M&V consultants. A significant amount of effort was directed to locating this information with some level of success. The RIA team held discussions with program managers to develop a better understanding of the records they maintain for each project and the information on file about each project sampled. Depending on the program and the project, information was also requested from third party M&V consultants, customers, and implementation contractors. This included M&V data, trend data, revisions to projects, equipment inventories, and equipment specifications. The information obtain from these other sources can be very useful as it can provide a more accurate understanding of the retrofit that occurred. The team attempted to obtain complete data records, but it was apparent that the received documentation was incomplete for many projects.

Sampling

The nested sampling metric was designed to meet the following objectives.

- ➡ 90% confidence interval and 10% precision at the portfolio level (all programs aggregated).
- ➡ 90% confidence interval and 20% precision for each program stream and the custom projects of under each program stream.
- ➡ 90% confidence interval and 30% precision for the prescriptive projects under each program. For the 2009 program year, only the ERIP program has prescriptive projects.

The sampling process is designed based on a ‘value of information’ approach. The goal is to focus on projects with non-lighting measures, high impact, and high uncertainty. The population is stratified by measure type, by kW savings and by building type. Building types are grouped by expected level of uncertainty in the reported savings estimates. For example, projects classified as Industrial, Agribusiness, Multi-Use, Universities, and Other are grouped at a ‘high level’ of expected uncertainty.

The following steps were taken to create the samples used in the impact evaluation.

1. Sample sizes were selected for each program to maintain 90% confidence and 20% precision at the program level. Programs with custom and prescriptive projects (ERIP) have sample sizes which maintain 90% confidence and 20% precision for the custom projects and 90% confidence and 30% precision for the prescriptive projects. Sample size was calculated based on the following formulae:

$$n = \frac{C_v^2 Z^2}{P^2}$$

where,

C_v = Coefficient of variance = 0.5 (assumed)

P = Precision = 20%

Z = Z-Statistic based on 90% confidence = 1.645

2. The population was stratified by measure type, by kW savings and by building type. The sample size for each stratum was calculated using a ratio estimation approach based on savings weights. A savings weighted approach ensures the high impact projects were selected for review.
3. The project population was initially stratified by measure type. All non-lighting projects were moved to a non-lighting project stratum and lighting projects were grouped in a lighting project stratum. For some programs, a kW savings threshold was developed to stratify the program by projects with large savings and projects with smaller savings.
4. Projects in each stratum were further stratified by building type (Industrial, Other, Multi-Use, Retail, Office, University, Other Commercial, Warehouse, Agribusiness, Other Institutional, Schools, Hospitality, Hospital). Building types were grouped by expected level of uncertainty in the reported savings estimates.
5. The sample size for each sub-stratum was calculated using a ratio estimation approach based on savings weights.
6. Each project was assigned a random number (using a standard statistical random number generation tool).
7. The random numbers were multiplied by each project's estimated demand reduction (from program records) to produce a rank for each project in each sub-stratum.
8. Projects in each sub-stratum were arranged by rank in descending order. Starting from the top, projects were selected per the assigned sample size. Alternates were also selected for each sub-stratum.

Customers were contacted to arrange on-site inspections three business days after program staff dispatched notification letters. After several attempts to reach customers, alternative projects were selected to replace the primary samples. Additional assistance was requested from program staff if needed.

File Review

A detailed review of the project files was conducted prior to the onsite inspections. Based on the file reviews, an onsite inspection plan and a metering plan were prepared for each project. The metering plan was informed by whether or not trend data for the equipment was available, the expected uncertainty in the equipment operating parameters, and the overall size of the project. For example, a lighting retrofit in a large warehouse without occupancy sensors has a low overall uncertainty compared to a lighting retrofit in a convention/conference center or a chiller retrofit with a variable speed drive. In addition, previously metered data were used whenever possible after verifying the overall credibility of the information. Inspection plans included site specific questions and goals for the inspection as well as an overall approach to be followed by the on-site inspector, including a set of applicable checklists and equipment specification forms. The project measure and energy savings information in the project files varied considerably among projects, even within the same programs. Due to the varied and sometimes limited reporting of project measures, equipment inventories, and energy savings, at times it was difficult to assess the scope of projects, assumptions, and calculations used to determine energy savings.

On-site Inspections

On-site inspections are an important component of the accurate evaluation of programs and represent a significant portion of the effort. Activities included:

- Collecting baseline and retrofit equipment information.
- Obtaining the operating parameters.
- Conducting a visual inspection.
- Gathering equipment nameplate information.
- Metering and data logging activities conducted per the evaluation plan.
- Conducting brief on-site interviews with relevant parties to understand the building operation, load shapes, equipment operating specifics, and other input parameters needed to calculate energy savings.

During the review of the sampled projects, the metering activities were clearly identified and planned before the visit. Light logging, spot power measurements, and amperage metering were conducted where it was determined to be practical and useful. In cases where good quality metered data were available from the program records, no additional measured data were collected. Locations which were logged were visited twice, once to install equipment for monitoring and then to pick up the equipment after monitoring.

On-site inspections were significantly affected by the availability of equipment inventories, specifications, and whether or not equipment inventories included locations for both the baseline and retrofit conditions. The availability of that information varied from project to project. When such information was not available, the on-site inspectors attempted to obtain it through interviews with site personnel and other observations during the on-site inspection. The equipment inventories available in the project files were often from the initial application. As some projects subsequently revised the inventory, the equipment inventories were not always up-to-date.

Engineering Calculations

The calculation approach involved verifying energy and demand savings for the sample and using a combination of sample and population information to estimate savings for the population based on a weighted average realization rate calculated for each program.

Verified Energy and Demand Savings for the Sample

Engineering analyses were conducted to determine the savings for each project. The analyses were informed by the best currently available baseline and retrofit information obtained. In some cases, potentially useful data did not arrive in time for interim results to be developed. Once such data are received, it may be possible to revise the analysis with the improved information. The ratio of the evaluation determined savings, or gross verified savings, to the program estimated savings for each project is the realization rate. Realization rates were calculated for each project included in the analysis. Savings-weighted averages of these realization rates produced the program and portfolio level realization rates.

Characterization of the baseline conditions presented challenges. In many cases, the project records inadequately described the baseline. Since the baseline equipment was not in place during the site inspections, it was difficult to accurately verify baseline information during the onsite inspections. Baseline equipment and its operation were characterized as well as possible during onsite inspections. These efforts were largely dependent on the presence of knowledgeable facility personnel. In all cases, the best available information including project documents, information obtained during the on-site inspection and industry standards, adjusted to actual on-site conditions, was used. The on-site inspections produced equipment counts (lighting fixtures, controls etc.) and operating parameters (equipment efficiency, lighting connected wattage, operating hours etc.) for retrofit equipment, which was often used to inform estimates of the baseline equipment and its operation.

For each project in the sample, first the gross energy savings were calculated based on site specific information. The demand savings were then calculated by developing equipment energy use load shapes. The load shapes were developed using site-specific equipment operating parameters (on/off times, reduced usage, partial load, etc.) to plot an 8,760 load profile. Using the 8,760 load profile, the average peak demand savings were calculated for the summer peak period of June to September 11 am to 5 pm on weekdays.1 Table 2 shows the time periods which are defined as peak, mid-peak, and off-peak during the winter, summer, and shoulder periods.

Table 2: Time of Use Periods

PERIOD	WINTER (DEC-MAR)		SUMMER (JUN-SEP)		SHOULDER (APR, MAY, OCT, NOV)	
	TIME	HRS	TIME	HRS	TIME	HRS
Peak	0700-1100 and 1700-2000 weekdays	581	1100-1700 weekdays	510	None	0
Mid Peak	1100-1700 and 2000-2200 weekdays	664	700-1100 and 1700-2200 weekdays	765	0700-2200 weekdays	1230
Off Peak	0000-0700 and 2200-2400 weekdays, all hours weekend and holidays	1659	000-0700 and 2200-2400 weekdays; all hours weekend and holidays	1653	0000-0700 and 2200-2400 weekdays; all hours weekend and holidays	1698

In order to develop the 8,760 load shape, a kW savings was calculated for each of the 8,760 hours of the year. By summing all the kW savings for the hours in the load shape associated with the summer peak time period, June – September from 1100-1700 on weekdays, the kWh savings for the summer peak period is calculated. The average peak demand savings is then calculated by dividing the summer peak period kWh savings by the amount of hours in the summer peak period. In 2009, there were 510 defined summer peak hours.

The resulting energy and demand savings were then compared with claimed savings estimates where possible. The ERIP and BIP program streams do not report annual energy savings, so only a comparison with the programs' claimed demand savings estimate was conducted.

The results presented in this report are based on engineering analyses for 75 inspected projects.

[1] System Co-incident Peak Demand defined by OPA. 2009. "Commercial and Institutional Measures and Assumptions" and "Mass Market Measures and Assumptions."

Extrapolating to the Population

The verification of energy and demand savings for the selected samples resulted in energy and demand realization rates for most program streams. Since the sample is representative of the population, the calculated energy realization rates were used to extrapolate the savings for the population. For programs which report both energy and demand savings for all projects in the population, both energy and demand savings were extrapolated for the population. As ERIP and BIP do not report energy savings for all projects, it was not possible to calculate an energy realization rate and extrapolate the energy savings for the population. Only demand savings were extrapolated for the population for those two program streams.

RESULTS

The overall realization rate for the portfolio demand savings as 92.5%. As shown in Table 3, the program demand realization rates of BBP, BIP, BOMA, and ERIP – C&I are 91.4%, 91.0%, 110.5%, and 90.5% respectively.

Table 3: Summary of 2009 Impact Evaluation Results

PROGRAM METRIC	BBP	BIP	BOMA	ERIP – C&I	TOTAL
ENERGY SAVINGS					
Program Reported Energy Savings (MWh)	28,498	n/a	20,430	n/a	48,928
Energy Realization Rate (%)	81%	n/a	103%	n/a	522%
Gross Verified Energy Savings (MWh)	23,188	21,790	21,124	189,338	255,439
Net MWh savings	**10,863**	**13,263**	**14,249**	**119,325**	**157,700**
DEMAND SAVINGS					
Program Reported Demand Savings (kW)	6,804	3,561	3,630	31,213	45,208
Demand Realization Rate (%)	89%	88%	112%	90%	91%
Gross Verified Demand Savings (kW)	6,065	3,143	4,050	27,978	41,235
NTG Ratio (%)	46%	61%	66%	63%	61%
Net kW savings	**2,797**	**1,904**	**2,689**	**17,648**	**25,037**
Measure Installation Rate	97%	98%	99%	96%	97%

DISCUSSION

Realization Rates

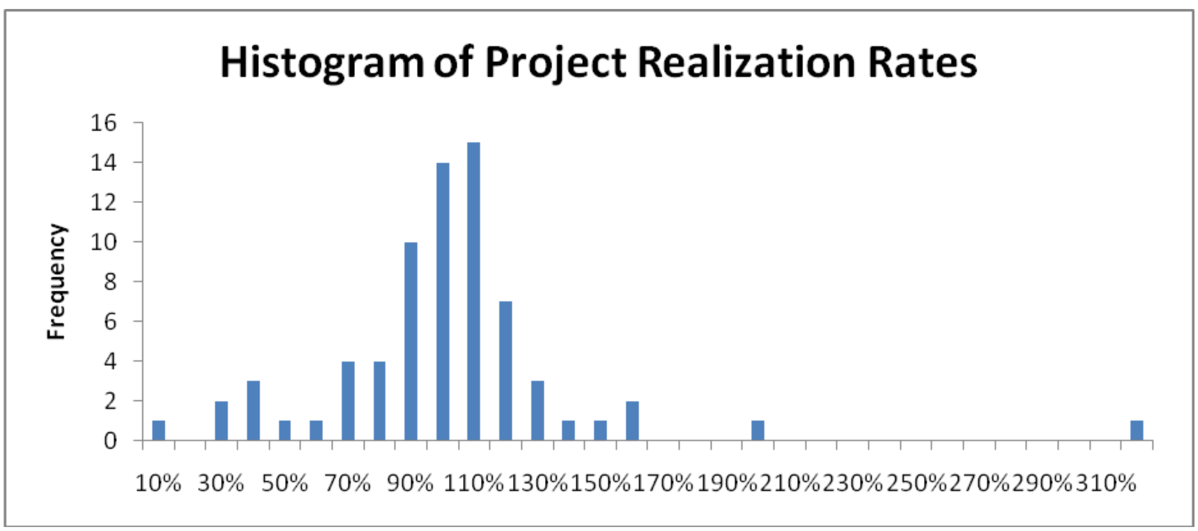
Three of the programs, BBP, BIP, and ERIP have similar demand realization rates with values in the low 90s, while BOMA's is 110.5%. The demand realization rates for non-lighting projects and lighting projects are between 90% and 110% except ERIP-C&I Prescriptive Non-lighting and ERIP-C&I Custom Lighting, Table 4. All the projects in the ERIP-C&I Prescriptive Non-lighting sample have the same measure, High Volume Low Speed (HVLS) fans, a discussion on those projects is included in the Measurement and Verification section.

Table 4: Demand Realization Rates for Non-lighting and Lighting Projects

DEMAND REALIZATION RATE	BBP	BIP	BOMA	ERIP – C&I CUSTOM	ERIP – C&I PRESCRIPTIVE
Non-lighting Projects	92%	93%	95%	96%	69%
Lighting Projects	91%	91%	110%	85%	98%

Examination of the realization rates of individual projects in each program reveals the range of realization rates in each program is quite large. The graph below, Figure 1, shows a histogram of the demand realization rates for all the projects. While the majority of projects have demand realization rates within the range of 80% and 120%, the number of projects outside the range is of concern.

Figure 1: Histogram of Project Realization Rates



Among all four programs, 48% of non-lighting projects sampled have realization rates between 80% and 120%, whereas 78% of the lighting projects sampled have realization rates in that range. It is not unusual for realization rates to be variable among non-lighting projects as such projects are often more complicated than lighting ones. Non-lighting projects have more factors which can vary greatly and significantly affecting their end-use consumption. Those factors include equipment loads, operating schedules, seasonal variations, changes to process loads, and baseline and retrofit equipment performance, etc.

Realization rates for demand savings less than 100% were often attributable to difference in the definition of "peak" savings. The project applications, aside from ERIP projects, would define the peak demand savings as the maximum possible kW savings among any of 8,760 annual hours. However, as described above, calculations for OPA gross verified savings the average peak savings across 510 hours defined by OPA as the summer peak period. Two common measures with misapplied demand savings were chiller replacement projects and lighting occupancy controls. Calculations revealed that these projects might have a singular hour where savings approach the projected demand savings listed in the application; however, these savings were not consistent across all summer peak hours.

Realization rates for demand savings more than 100% were often attributable when the project application stated an overly conservative estimate of demand impacts by either a conservative estimate of baseline conditions or intentionally derating of peak impacts. Common measure examples include lighting equipment retrofits and building automation savings where applications assume zero demand benefits.

It is recommended that OPA standardize definition of demand peak impacts utilizing applications which inform the applicant of peak impacts. The custom ERIP application is an example of transparent definition of peak benefits to OPA.

Documentation

Another conclusion from the large range of realization rates among both lighting and non-lighting projects points to more uniformity and detailed documentation of project savings, baseline and post retrofit conditions. Inadequate documentation was found across all four programs and in both lighting and non-lighting projects. Some examples of inadequate documentation found include:

- ➡ Lack of equipment specifications, pre and post retrofit
- ➡ Omission of equipment quantities
- ➡ Revisions to project scopes not recorded
- ➡ Missing calculation formulas and assumptions used to determine energy savings
- ➡ Incomplete documentation for revisions claimed savings

Improved documentation would help program staff and M&V evaluators ensure projects are being credited with a more accurate savings estimate. For example, lighting inventories would help program staff and M&V evaluators identify discrepancies in equipment counts, baseline equipment, retrofit equipment, operating hours, savings calculations, and revisions to the scope of work. Currently that information is not always recorded.

Documentation of scope and savings revisions was found to be an issue. Currently documentation on project revisions is maintained for a few projects. The project descriptions included in project files are usually just the description from the initial application. However, a number of projects evaluated changed the scope of work of the project from the initial application and these changes were not reflected in program documentation and claimed savings were not adjusted accordingly. Revisions to the scope of work can result in significant changes in the demand and energy savings of the project, making it essential that changes in the scope of work be recorded and included in the project files. Since it is quite common for projects to undergo a revision in scope, it is worth requiring documentation on changes to project scope and energy savings.

There were numerous issues seen specific to various projects, but throughout the programs, there was one predominate common issue: inadequate documentation. It is recommended that the following documentation be maintained and updated with any project revisions for each project:

- Equipment inventory: pre and post-retrofit
- Equipment specifications: pre and post-retrofit
- kW and kWh savings calculations and assumptions (for custom projects)
- if applicable, M&V data and calculations

The various M&V requirements among the four programs should be reviewed, and possibly standardized. In particularly, the M&V requirements for large projects and large non-lighting projects should be analyzed, with the possibility of requiring long-term M&V for certain measures.

DOCUMENTATION

The cost effectiveness of the OPA C/I cross-cutting programs is discussed in the following section in terms of the total resource cost test (TRC), the program administrator cost test (PAC), and the levelized program delivery costs.

Total Resource Cost

The total resource cost (TRC) test measures the net costs of a program as a resource option based on the total costs of the program, including both the participants' and the utility's costs.[2] In general, it is the ratio of the discounted total benefits of the program to the discounted total costs over a specified time period. A benefit-cost ratio above one indicates that the program is beneficial to the utility and its ratepayers on a total resource cost basis.

The benefits calculated in the TRC test are the avoided supply costs, the reduction in transmission, distribution, generation, and capacity costs valued at marginal cost for the periods when there is a load reduction. The costs associated with this test are the programs costs paid by both the utility and the participants; this includes all equipment costs, installation, operation and maintenance, and administration costs, no matter who pays for them.

In algebraic form:

$$Benefits = \sum_{t=1}^{N} \frac{UAC_t}{(1+d)^{t-1}}$$

$$Costs = \sum_{t=1}^{N} \frac{PRC_t + PCN_t}{(1+d)^{t-1}}$$

$$TRC = \frac{Benefits}{Costs}$$

where

UAC_t = Utility avoided supply costs in year t

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[2] *California Standard Practice Manual: Economic Analysis of Demand-Side Management Programs and Projects*. July 2002.

PRC_t = Program administrator program costs in year t

PCN_t = Net participant costs in year t

d = Nominal discount rate (real discount rate adjusted for inflation)

Table 5 displays the inputs and result of the TRC test for the OPA C/I cross-cutting programs.

Table 5: Total Resource Cost Summary

PROGRAM METRIC	BBP	BIP	BOMA	ERIP – C&I	TOTAL
Benefits ($m)	$11.59	$7.21	$12.07	$95.22	$126.08
Costs ($m)	$32.14	$4.75	$13.46	$98.22	$148.57
Net Benefits ($m)	-$20.55	$2.46	-$1.39	-$3.00	-$22.48
Benefit Ratio	0.36	1.52	0.90	0.97	0.85

Of significant note is the negative net benefit of the OPA C/I cross-cutting program, resulting in an overall program total resource cost/benefit ratio less than 1.0. A more detailed review reveals that the cause of the negative net benefit is largely due to high customer costs, which are included in the TRC effectiveness analysis. In particular, BBP TRC costs comprise 91.5% of the overall C/I negative net benefits. Further, a comparison of the BBP customer costs levelized for the energy impacts is summarized in Table 6.

Table 6: OPA C/I Cross-Cutting Customer Costs

PROGRAM METRIC	BBP	BIP	BOMA	ERIP – C&I	TOTAL
$/MWh (Lifetime)	$254.40	$41.31	$75.52	$68.17	$80.87
$/kW-y	$11,123.47	$2,228.56	$4,067.65	$4,985.22	$5,362.85

Data from Table 6 reveals that BBP customer costs are 315% of the overall population levelized for energy (MWh) and 210% levelized for demand (kW). The Nexant team believes that the customer costs for the OPA C/I cross-cutting are not well vetted and likely include non-energy efficiency improvement customer costs.

Program Administrator Cost

The Program Administrator Cost (PAC) test measures the net costs of a program as a resource option based on the costs incurred by the program administrator and excluding any net costs incurred by the participant. A benefit to cost ratio above one indicates that the program would benefit the combined administrator and utility's total cost environment.

The benefits calculated in the PAC test, just as in the TRC test, are the avoided supply costs of energy and demand. The costs associated with this test are the program costs incurred by the administrator and the incentives paid to the customers.

In algebraic form:

$$Benefits = \sum_{t=1}^{N} \frac{UAC_t}{(1+d)^{t-1}}$$

$$Costs = \sum_{t=1}^{N} \frac{PRC_t + INC_t}{(1+d)^{t-1}}$$

$$PAC = \frac{Benefits}{Costs}$$

where

UAC_t = Utility avoided supply costs in year t

PRC_t = Program administrator program costs in year t

INC_t = Incentives paid to participants in year t

d = Nominal discount rate (real discount rate adjusted for inflation)

Table 7 displays the inputs and result of the PAC test for the OPA C/I cross-cutting programs.

Table 7: Program Administrator Cost Summary

PROGRAM METRIC	BBP	BIP	BOMA	ERIP – C&I	TOTAL
Benefits ($m)	$11.59	$7.21	$12.07	$95.22	$126.08
Costs ($m)	$3.29	$1.28	$4.19	$17.09	$25.84
Net Benefits ($m)	$8.30	$5.93	$7.88	$78.13	$100.24
Benefit Ratio	3.53	5.63	2.88	5.57	4.88

Levelized Delivery Cost

Levelizing the costs of the cross-cutting programs is a useful way to express the program delivery costs per unit of energy savings. From OPA's perspective, the levelized delivery costs will be useful when comparing this program to others in their demand-side management portfolio.

Program delivery costs are program administrator costs and incentives paid to the participants are identified as costs in Table 7.

To levelize these costs for energy and demand savings, we follow the following formula[3]:

$$Levelized\ Delivery\ Costs = \frac{Delivery\ Costs}{\sum_{t=1}^{N} \frac{Q_t}{(1+d)^{t-1}}}$$

where

Q_t = Energy or capacity savings in year t

d = Nominal discount rate (real discount rate adjusted for inflation)

Table 8 summarizes the levelized costs for the OPA C/I cross-cutting programs.

Table 8: Levelized Delivery Costs

PROGRAM METRIC	BBP	BIP	BOMA	ERIP – C&I	TOTAL
$/MWh (Lifetime)	$26.88	$12.46	$28.93	$13.24	$15.57
$/MW-y	$1,175,326	$672,322	$1,558,262	$968,245	$1,032,242

[3] Short, Walter, et.al. *A Manual for the Economic Evaluation of Energy Efficiency and Renewable Energy Technologies*. National Renewable Energy Laboratory. March 1995.

3 MEASUREMENT AND VERIFICATION

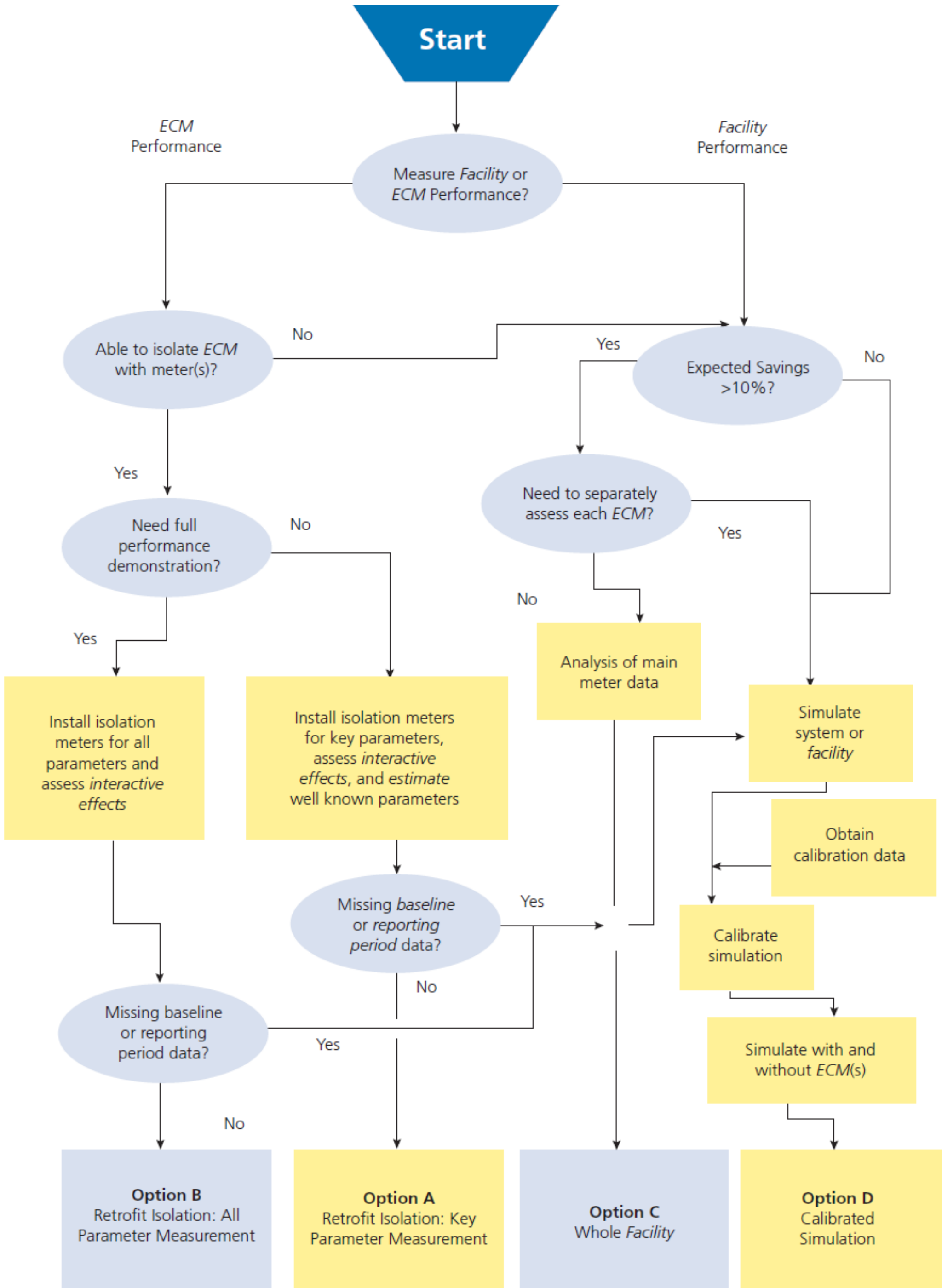
The selection of what M&V approach to take for each project was informed by the information gathered during the file review and onsite inspection and the limitations of the time frame. The M&V approach for each project was selected based on information gathered during the file review and onsite inspection, in which the project intricacies, including savings levels and type measures installed are examined. The M&V methods used in this evaluation adhere to the International Performance Measurement and Verification Protocol (IPMVP). The IPMVP options used during the impact evaluation are as follows:

- Option A: Partially Measured Retrofit Isolation – End-Use Measurements, Some Stipulations.
- Option B: Retrofit Isolation – Complete End-Use Measurements.
- Option C: Whole Building – Energy-Use Analysis on Multiple Systems.

In cases where sufficient data were not available or the specific end-use technology did not warrant a metering approach, an entirely stipulated or deemed savings approach may have been used. Figure 2 shows the decision tree used to select the M&V method. The goal was to perform M&V or obtain trend data from each site, where possible. A few reasons why it was sometimes not possible to conduct M&V were: customer refusal, inability to access equipment on ceilings, safety concerns, disruption to the facility's activities, and inability to access the points to make measurements, etc. Due to the short time frame, metering activities were limited to short-term measurements. The following measurement goals were developed for sites where measurement was feasible.

- Lighting projects were logged for one week. The type of logging was either on/off logging or light level logging, depending on the details of the measure and its installation.
- Non-lighting projects
  - Obtain trend data from the equipment management system or the M&V contractor.
  - Billing data, if the savings represented a significant amount of the building's energy consumption.
  - Spot measurements of the kW, amp, voltage, and/or power factor.
  - Amp and/or temperature logging for one week.

Figure 2: IPMVP Flow Chart



Since long-term trend data are the most useful of data available for non-lighting projects, long-term trend data were always used if they were available. A verification of the installation of the energy efficiency equipment was conducted at each site inspection. The quality of the verification was dependent on the project information provided by the programs. At times, due to lack of adequate information to conduct a verification of the installation, supplemental information was sought from program customers. Verifications of the counts and nameplate data of the equipment installed were conducted for each sampled project. Any removal of the retrofit equipment was also noted. At sites with numerous equipment replacements, it was necessary to sample the equipment. When sampling was conducted, every effort was made to focus on the parts of the project with the largest savings.

High Volume Low Speed (HVLS) Agricultural Quasi-Prescriptive Measure

OPA assumes the same delivered airflow in both the baseline (box fan) and retrofit (HVLS) conditions[4]. Based on the fans observed in the field, a ratio of the number of box fans to the number of HVLS fans on the order of 16:1 is required to deliver equivalent airflows in both scenarios. However, our background research and field experience do not support this assumption.

The following references are provided to support a lower ratio:

1. A range of 8:1 to 12:1 is stated in 'Cooling Effectiveness of High-Volume Low-Speed Fans Versus Conventional Fans in a Free-Stall Dairy Barn in Hot, Humid Conditions', Worley and Bernard, The Professional Animal Scientist 24 (2008): 23-28.
2. 'Cooling Systems for Georgia Dairy Cattle' by Worley recommends HVLS spacing of 60 feet along the length of the barn. 'Design of High Volume Low Speed Fan Supplemental Cooling System in Dairy Free Stall Barns' by Kammel, et al. states that conventional fans are typically placed every 30-40 feet along the length of the barn. A conservatively high number of six conventional fans across the width of the barn would result in a baseline-to-HVLS fan ratio of only 12.
3. 'Ventilation Fans for Animal Housing' from Wisconsin's Focus On Energy mentions a ratio of 6:1. While it is stated that this ratio would deliver the same airflow, it seems more likely that the ratio was based on common field installations, because none of the manufacturer's data from the HVLS and typical box fans or even ceiling fans would

4 2010 Quasi-Prescriptive Measures and Assumptions, Release 1, January 2010, p. 19-20.

support the same airflow at this low ratio. It is provided here simply as another reference stating a much lower range for this ratio than the assumed 16:1.

Moreover, the three site visits revealed even lower ratios of 2:1, 1:1, and one installation that had no fans prior to the installation of the HVLS fans. As shown in the analyses for these projects, demand savings essentially vanish at these low ratios. The higher efficiency (CFM/W) of the HVLS fans is dwarfed by the significant increase in airflow; the result is higher power consumption at full load, albeit at a higher efficiency than the baseline.

Energy savings can sometimes still be present because of the ability of the HVLS variable speed drives to reduce power consumption at part load conditions. Even at the higher airflows of the HVLS fans, the drives are able to reduce the power consumed at low loads below that consumed by the constant speed baseline fans. If enough part load hours exist (based on weather and the control strategy employed by the HVLS fans), energy savings can still accrue even though demand savings may not be present at peak load.

A complicating factor found in the literature is the presence of misting systems to enhance the cooling effect on the cows. Delivering the same amount of cooling can be accomplished with less airflow when these misting systems are employed. This factor warrants further consideration, although none of the three installations that were inspected used misting.

Nexant's analysis indicates that the HVLS measure, while generating energy savings under the right conditions, may not be appropriate as a peak demand savings measure. At minimum, Nexant recommends that OPA reclassify HVLS fans as a custom measure, so that site conditions can be fully accounted for when determining project savings.

4 FREE-RIDERSHIP AND NET-TO-GROSS

This section describes the methodology for calculating free-ridership and how it was used to calculate net-to-gross ratios and net savings.

FREE-RIDERSHIP METHODOLOGY

Attribution was assessed using a brief instrument that assesses two components of free-ridership: 1) intention to carry out the energy efficient project without program funds; and 2) influence of the program in the decision to carry out the energy efficient project. Intention was assessed through three brief questions:

1. Had the respondent ever considered replacing the measure in question before being contacted by the program representative?
2. Had the respondent planned to replace the measure in question before being contacted by the program representative?
3. How the project likely would have differed if the respondent had not received the program incentive, from no change (would have done the project exactly as it was done) to reduced project scope or size or used less expensive or efficient equipment to cancelled the project altogether.

Program influence was assessed by asking the respondent how much influence – from 1 (no influence) to 5 (great influence) – the program incentive, the assessment, and the respondent's interaction with the contractor had on the decision to do the project the way it was done.

The following algorithms were applied to the responses to the two sets of questions to generate a "project change" score and a "program influence" score:

Project Change. Respondents received "project change" free-ridership score ranging from 0 to 50. They received a maximum "project change" free-ridership score of 50 if:

➡ They had already installed the equipment before contact with the program.

➡ They had planned to install the equipment before contact with the program and did not describe how the project would have been different without program contact.

➡ They would not have done the project any differently without program contact and said their firm would have paid the entire cost of the project or did not answer whether the firm would have paid the entire cost.

Respondents received a "project change" free-ridership score of 37.5 if:

- They would not have done the project any differently without program contact and said their firm probably would not have paid the entire cost of the project.

Respondents received a "project change" free-ridership score of 25 if:

- They would not have done the project any differently without program contact and said their firm definitely would not have paid the entire cost of the project.
- They would have done a smaller project or one with less costly or less efficient equipment.
- They responded to other survey questions but not "project change" questions.

Respondents received a minimum "project change" free-ridership score of 0 if:

- They would not have done a project, cancelling or postponing at least one year any planned projects.

Program Influence. Program influence was calculated as the maximum influence score given for any of the three "influence" factors. Respondents received a "program influence" free-ridership score ranging from 0 to 50, based on their maximum influence score, as follows:

- Maximum influence = 1, Program influence free-ridership = 50
- Maximum influence = 2, Program influence free-ridership = 37.5
- Maximum influence = 3, Program influence free-ridership = 25
- Maximum influence = 4, Program influence free-ridership = 12.5
- Maximum influence = 5, Program influence free-ridership = 0

The "project change" and "program influence" scores were summed for each respondent, resulting in a total free-ridership score ranging from 0 to 100. The number is interpreted as the percentage likelihood that a given respondent is a free-rider.

NET-TO-GROSS CALCULATION

After realization rates and free-ridership scores were calculated for each project, they were weighted by savings to determine the realization rate and free-ridership share for each program's measure category, lighting or non-lighting. Those rates at the measure level were then applied to the reported measure savings values and reweighted to calculate the program-level realization rates and free-ridership shares. Finally, the realization rates and free-ridership rates were aggregated for all four program streams by reweighting values by savings as applicable. Table 9 summarizes reviewed projects by savings strata and program.

Table 9: Reviewed Projects by Savings Strata

PROGRAM STREAM	MEASURE CATEGORY	QUANTITY REVIEWED	TOTAL QUANTITY	REVIEWED SAVINGS (KW)	REPORTED SAVINGS (KW)
BOMA (Custom)	Lighting	10	53	905	2,453
	Non-Lighting	5	27	525	1,177
BIP (Custom)	Lighting	9	66	530	1,997
	Non-Lighting	7	15	1,467	1,565
BBP (Custom)	Lighting	5	53	940	2,599
	Non-Lighting	10	51	2,812	5,037
ERIP (Prescriptive)	Lighting	7	652	786	12,036
	Non-Lighting	3	126	409	4,996
ERIP(Custom)	Lighting	9	164	1,431	7,658
	Non-Lighting	10	46	2,010	6,522