



Impact Evaluation Report

2009 Energy Design Assistance Program in Colorado – Impact Evaluation and Net-To-Gross Assessment

Final Report

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Acting agent for Public Service Company of Colorado

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1. Introduction

This final report is the deliverable for the impact evaluation of the 2007 to 2008 Xcel Energy – Energy Design Assistance (EDA) Program as delivered in Colorado (CO). A final process evaluation report was delivered to Xcel Energy as a separate document.

The primary purpose of the EDA Program impact evaluation was to review the documentation available and determine what adjustments to the reported savings were necessary to more accurately calculate the actual savings attributable to the program on a participant basis. This was accomplished in conjunction with the net-to-gross (NTG) analysis, which calculated the fraction of total savings that could be assigned to the immediate effects of the program in the marketplace.

Xcel Energy keeps a comprehensive set of program design and construction documents for each project (i.e., each participant). It was initially assumed in the KEMA scope of work that the EDA consultants would be willing to provide other detailed design information to aid in the evaluation process. In particular, the consultants use the hourly building energy simulation code known as Department of Energy 2 (DOE2) to calculate hourly savings for a comprehensive list of potential energy conservation strategies for each participating project. They examine the savings and costs for each of these strategies and compile three or four lists of strategies, called bundles, which exhibit favorable benefits at reasonable costs and payback periods. These bundles include only the strategies that passed an initial screening process to identify those that qualified. The first bundle is the least aggressive in terms of overall savings, and the least cost. The other bundles progress to more aggressive project savings and higher construction costs. This strategy allows the building owner to choose a bundle best suited for a particular set of priorities.

Knowing that much of the detailed information regarding individual strategies would be contained within the DOE2 input files, KEMA contacted the EDA consultant that had been responsible for most of the projects and asked if they would be willing to release copies of those files. The request was declined since this had not been a requisite of their contract, and, they expressed concerns that it could pose a breach of proprietary information. This evaluation, therefore, is based solely on the project documentation available from Xcel Energy.

At the time of this evaluation there were 28 completed Colorado projects on record in the Xcel Energy data tracking system. The following table lists the projects completed, representing the total participant population as of September, 2009:

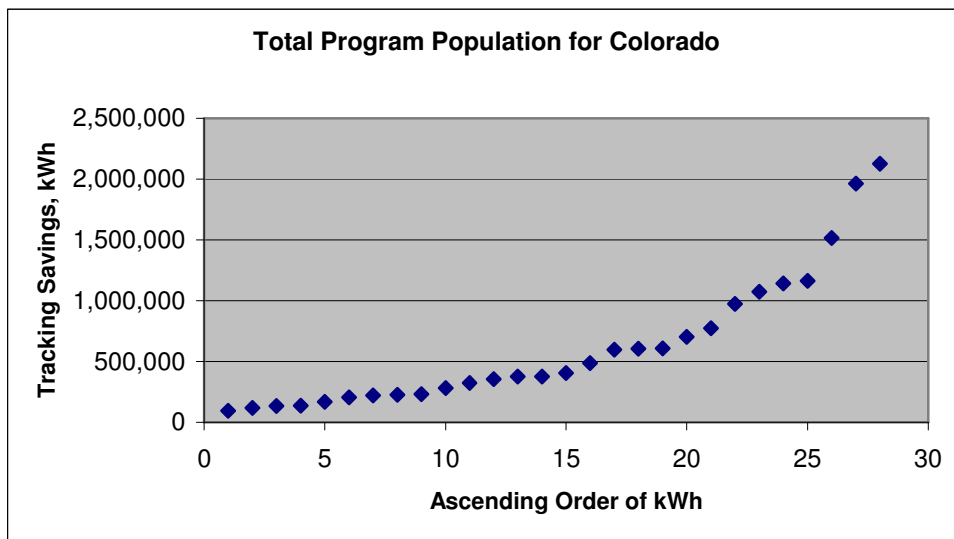
Table 1: Total Program Population - Colorado

Sample Participant Population Count	Marketing kWh	Stratum
1	94,997	1
2	119,286	1
3	133,958	1
4	136,112	1
5	167,809	1
6	204,689	1
7	222,130	1
8	226,306	1
9	232,697	1
10	281,167	2
11	324,852	2
12	355,961	2
13	376,771	2
14	376,955	2
15	406,380	3
16	486,918	3
17	598,034	3
18	607,085	4
19	609,253	4
20	704,626	4
21	774,882	5
22	973,675	5
23	1,075,744	6
24	1,143,968	7
25	1,164,872	7
26	1,513,906	8
27	1,962,005	9
28	2,124,977	10
Sum: CO	17,400,015	

To minimize evaluation costs, it was necessary to evaluate a representative sample of the 28 projects, obtaining a sampling precision of at least 90/10 (precision of +/- 10% with a confidence level of 90%) based on tracking system savings.

A preliminary look at the tracking savings for these participants indicated that the population was somewhat skewed, favoring projects with small and medium savings, with a few very high yield projects. The next graph shows the tracking savings for each project for Colorado in ascending order.

Table 2: Tracking Savings - Colorado



There were two or three relatively large projects in the population, and the distribution is clearly non-linear. These imposed some challenges to the sampling plan, which is discussed in the Methodology section.

2. Evaluation Objectives

The primary objectives of this impact evaluation are to calculate Xcel Energy’s gross and net savings impacts associated with the EDA program in Colorado and over a set period of time; verify that Xcel Energy’s baseline measure technical assumptions used for calculating gross and net savings are acceptable; calculate net-to-gross (NTG) ratios, including the effects of free-riders, free-drivers and spillover; and determine if the NTG ratios are in-line with other similar programs, based on previously acquired knowledge KEMA has from similar evaluations.

For the purpose of this impact evaluation report, the stated impact evaluation researchable objectives were addressed under two components; an Impact Analysis and a Net-To-Gross Assessment, each treated independent of, but in conjunction with, one another. The table below shows the goals and sources for these assessments.

Table 3: Impact Evaluation - Goals and Sources

<i>Impact Analysis</i>	<i>Data Source</i>
Recalculate Xcel Energy’s gross savings associated with the EDA program	Project files (EDA participants)
Determine if Xcel Energy’s baseline measure technical assumptions were valid	Project files & Delphi study
Investigate resulting gross and net savings; compare to other similar utility programs	KEMA research
<i>Net-To-Gross Assessment</i>	<i>Data Source</i>
Net to gross factors – Free Riders	Participant Surveys
Net to gross factors - Spillover	Participant Surveys
Net to gross factors – Free-drivers	Included in Spillover

3. Methodology

3.1 Scope of Work

The research scope of the impact analysis component of this study was divided into three separate tasks aimed at addressing the researchable questions given for this evaluation. Since a number of research goals were requested by Xcel Energy, KEMA designed this study in a manner that employed both quantitative and qualitative protocols.

This scope of work was first developed and submitted to Xcel Energy for review and approval, and then implemented. The work plan identified the goals and researchable questions that would be addressed through each of the Impact and Net-To-Gross surveys, interviews and secondary sources. Progress reporting, communications procedures, and a draft work plan were also established.

The nature of the impact evaluation required that the tasks be segregated into two components – an Impact Analysis and a Net-To-Gross (NTG) Assessment - which allowed for a more effective and streamlined work scope. Specifically, to collect data for the Net-To-Gross component, some tasks were performed concurrently with those of the Process Evaluation, which will be delivered in a separate report.

The research steps for the impact evaluation were divided into the following tasks:

- Conduct a project initiation meeting; develop and deliver a finalized work plan;
- Provide management and progress reporting;
- Calculate gross and net savings over time;
- Verify baseline and technical assumptions; and
- Calculate Net to Gross ratios.

3.2 Research Steps

The following sections provide information about the research steps taken to help address Xcel Energy's EDA researchable impact analysis questions.

3.2.1 Solicitation & Data Acquisition

To set up for the Net-To-Gross (NTG) free-rider and spillover surveys, KEMA employed the following research procedures:

- Developed a stratified, sector-specific sampling list and solicitation methodology;
- Developed interview guides which assisted with addressing the researchable questions, and calculating the overall NTG ratio;
- Created and distributed preliminary solicitation letters with the help of Xcel Energy;
- Performed e-mail and/or phone solicitations while tracking interviewee response rates; and
- Recorded interviews for analysis and for the NTG calculations, using a tool developed specifically for this analysis.

The survey questions pertained to decisions made by the building owners or developers during the EDA process. Participants were asked to rate the importance of the program as well as other factors that might have influenced their decision to conduct a detailed engineering analysis and implement recommended energy efficiency measures. The survey addressed:

- The influence of corporate policies, standard industry practices and general concerns about the environment to implement energy efficiency measures;
- The likelihood that a participant would have implemented the same, or alternative energy efficiency measures had they not participated in the EDA program or if an incentive had not been available;
- A comparison between the importance of the factors referenced above and the importance of the EDA program in their decision making; and
- The amount of energy efficiency that a participant was able to achieve or would have achieved without any assistance from Xcel Energy's EDA program or other programs.

EDA program participant recruitment for this survey began simultaneously with recruitment for the process interview. Initially, participants who qualified were scheduled to complete a twenty to thirty minute interview which included both a Process Analysis section and an NTG survey. As recruitment progressed, we experienced a low participant response rate. As a result, KEMA chose separate efforts of recruitment for the Process interview and NTG survey.

Upon completion of the NTG survey, interviewees were given an honorarium in the form of a \$50 money order gift.

3.3 Task Methodology

This section describes the approach used by KEMA to calculate project impacts based on the information available.

3.3.1 Impact Analysis

Initial gross impacts for each of the participant sites had been calculated by DOE2 energy modelers during the early design phase of each project. For this analysis, KEMA was required to recalculate gross energy and demand savings and NTG ratios for a representative sample of the participant projects. Net savings were then calculated by first calculating NTG ratio, and using it to adjust the new program-wide gross savings estimate at the program level.

For this task, KEMA examined the program database to identify all fields so that KEMA could tag the data needed for the impact analyses. Individual project design files for all sample projects under this task included strategy reports, bundle reports and final verification reports, as well as memos and other communications. Although the DOE2 input files were not made available to KEMA, some DOE2 modeling information was included within the stated documentation.

The review of this documentation provided a double check of the program tracking system values for each measure by comparing the tracking system values to the estimates contained in the program files. During this stage, required documentation adjustments were revealed. KEMA assessed the appropriateness of the applied engineering factors and assumptions in determining energy savings and demand impacts, and checked them for consistency with the EDA program savings documentation.

Verifying Baseline and Technical Assumptions

For energy code baseline standards, KEMA reviewed the most recent energy codes that apply to the Colorado program and verified that the appropriate minimum prescriptive standards were used by the evaluation engineers in establishing savings for the EDA program.

For market-driven baseline standards, KEMA assessed the baseline parameters for the EDA through a modified Delphi Study¹. This consisted of interviewing those who, collectively, know the Xcel Energy service area, and included the design professionals who had been recently and directly involved with new commercial and industrial building construction and major renovation, and the EDA consultants who have recently calculated energy savings for program participants.

KEMA enlisted thirteen building professionals to take part in the study, including participating and nonparticipating architects and energy engineers. Our goal was to solicit five of each of the above stated professionals and five building contractors for this study, but none of the building contractors responded to the invitation.

KEMA created a battery of specific questions for the modified Delphi process. Each participant was asked to answer a limited number of focused quantifiable questions. Once the individual responses were compiled, KEMA presented them back to each participant for further review and comment, allowing each to adjust the previous response in the light of the opinions of the others in the group, providing their own reasoning for remaining differences between their opinion and the average responses.

Lastly, KEMA prepared a second tally of results that showed individual arguments and the new average results. Each participant had one last chance at agreeing with the averages or presenting more compelling evidence of their opinions if they still differed significantly from the general averages. From this last round of responses KEMA conducted weighted averages, with the weights adjusted depending on how convincing the final arguments were for any significant differences. The weighted results were assumed to be the best estimates and were reported back to the participants for their own information.

Verification of Technical Assumptions

For each participant in this program, Xcel Energy thoroughly reviewed all documentation that had been created to estimate and report the program impacts in order to calculate a suitable rebate. This process required the application of hundreds of technical values and assumptions, which KEMA also considered and verified during the detailed review of the sample file documents.

3.3.2 Net-To-Gross Assessment

The following provides an overview of the steps taken to assess free-rider effects of the program based on the elements of the California self report protocol and the KEMA self report protocol. Additionally, KEMA modified another self report protocol to discover and quantify spillover. This task was aimed at adjusting gross energy and demand savings at the whole program level by calculating a combined Net-To-Gross (NTG) ratio.

Survey Design & Assessment Tool

The questions prepared for the NTG assessment were fashioned to address the higher level decision-making process that is characteristic of the EDA program, but were initially derived

from a non-residential NTG Methodology Decision Maker Survey approved for official use in California. The California survey was designed for a measure oriented type of conservation program with a battery of questions focused on individual measures as the basis of assessing free-ridership. However, since this is not characteristic of the EDA program, modifications were made to ensure that the EDA survey consisted of program specific questions consistent with the operating strategy of the program. The KEMA survey also included appropriate questions designed to identify spillover for this type of program.

As interviews were conducted, the information from the participant impact surveys was collected and transferred into an NTG calculator that was developed for the purpose of calculating free ridership, and which included a tab for independently calculating participant spillover.

Sampling Methodology

To minimize the cost of the task for the NTG and Spillover sampling strategy, KEMA originally devised a statistical sampling plan based on the tracking estimates of annual energy savings that provided an initial sampling precision of 10% at a confidence level of 90% for all participating projects. Low responses required KEMA to create an alternate sample for soliciting additional NTG survey participants. A total of 10 interviews were conducted to achieve a 90% confidence level with a 10.2% relative precision of error.

Building owners were the most appropriate contact to query on these decisions given the assumption that they would make the final decision to participate. This decision to participate, however, could have been due to the influence of a design engineer who was familiar with the program, or even prior to the involvement of a design engineer. Therefore, design professionals such as the design engineers and project architects were asked to participate as well since they often acted upon the building owners expressed desires to create an efficient building without regard to any specific measure or strategy.

Integration of Protocols

Modified California and KEMA protocols were applied independently to obtain savings in two ways. The first protocol was a highly modified California method to assess freeridership and yield a partial NTG ratio (net of free-riders). The KEMA protocol was an approach previously used in other evaluations, and modified to adapt to this type of program. Both methods originally assessed freeridership for measure-specific programs, as well as targeted individual measures to assess freeridership indicators for each measure. The modifications to both protocols were required to accommodate the decision-making motives and strategies at a

higher level, with savings based on a highly variable list of measures that were screened and selected based on their combined impacts and costs.

Another protocol, or battery of questions, was similarly modified from a measure-specific KEMA protocol to assess and quantify participant spillover. The two protocols were used to calculate a combined NTG ratio (net of free riders, and including spillover).

Secondary Sources: NTG Comparison to Similar Programs

In addition to estimating this program's combined NTG ratio, KEMA researched other studies it has performed for similar commercial/industrial programs to compare and make meaningful recommendations to Xcel Energy. A review of those results is shown later in this report.

4. Impact Evaluation

4.1 Sampling Plan

To properly represent the Colorado population with limited samples, KEMA chose to apply a sampling strategy allowing up to ten strata. This worked out well, and it was found that a sample of seventeen projects guaranteed the desired sampling precision assuming the projects within each stratum would have to be picked at random.

It was also decided that the impact sample should coincide as much as possible with the survey sample that was used in the process evaluation. This would allow the two aspects of the EDA combined process and impact evaluation to be more representative of the same sample, and gain the advantage of using the process survey information to aid in the impact evaluation.

It turned out, however, that the process evaluation sample could not be easily captured within the impact sampling strata limits due to the free choice of the targeted participants to respond (i.e. not required by the program to agree to participate in a post-project evaluation) and a subsequent low response rate.

The initial stock of project documentation contained primarily participants in the process and NTG combined interviews, and these were utilized as much as possible in the impact samples. When the initial delivery of project documentation samples was nearly exhausted, it became evident that some of the upper end strata in the Colorado impact sample had not been picked. At that point, KEMA hand picked the remaining sample points required to complete the Colorado sample.

The final sample for Colorado is shown in Table 4, with some sampling statistics shown at the bottom. The Stratum and Sample Weights are included in these lists so that the total program savings could be calculated as the sum and the mean bias error (MBE) could also be shown. As shown, the MBE is about -1% for the sample. This is significantly better than required (+/- 10%), but it was possible to minimize the bias error by hand-picking the last few sample points to do that. After all ten strata in the sample had been populated and the resulting MBE proved to be quite small, it became apparent that only twelve sample points would be necessary for the impact evaluation.

Table 4: Adjusted Impact Participant Sample

Sample Count	Marketing kWh	Stratum	Sample Weight	Tracking Savings
1	133,958	1	3.000	401,874
2	167,809	1	3.000	503,427
3	226,306	1	3.000	678,918
4	281,167	2	5.000	1,405,835
5	486,918	3	3.000	1,460,754
6	607,085	4	3.000	1,821,255
7	973,675	5	2.000	1,947,350
8	1,075,744	6	1.000	1,075,744
9	1,164,872	7	2.000	2,329,744
10	1,513,906	8	1.000	1,513,906
11	1,962,005	9	1.000	1,962,005
12	2,124,977	10	1.000	2,124,977
			Sum	17,225,789
			MBE	-1.00%

The “Tracking Savings” representing each sample point in the table is the Marketing kWh times the Sample Weight. For this sample, the sum of “Tracking Savings” minus the sum for the population and then divided by the sum for the population yields the MBE shown in the table. The final impact calculation error was, of course, neutralized by dividing each sample point by the MBE. The large number of strata utilized in the sample also assures reasonably close agreement in the distribution of savings between the population and the sample.

4.1.1 Documentation

Xcel Energy was able to provide extensive documentation for each of the sample projects, including strategy reports, bundle reports and final verification reports, as well as memos and other communication documents that allowed KEMA to follow the flow of each project from initiation through final construction and on-site verification.

In most cases, the DOE2 impact results were available in the strategy reports or in the bundle reports for each strategy that was actually installed. In a few instances, however, when plans were changed at a relatively late date in the process, some of the strategies were adjusted, yielding slightly different savings. In those cases, the final verification reports provided savings in terms of percentages of the total project savings. These percent savings were used only as necessary because they provided only one or two significant digits.

4.1.2 Recalculation of Impacts

The final verification reports contained the final design values and observed (installed) values utilized for each applied strategy. The reports also indicated whether the strategy was fully or partially implemented. An example would be a project report that describes square feet of lighting control retrofit areas designed, and then final areas actually retrofitted and verified.

The baseline values applied in the strategy stage of the process and utilized in the DOE2 savings models were listed in the Strategy Reports. Some of the strategies were not defined by energy code baselines because they were not required by code to be installed. These strategies included occupancy sensor, carbon monoxide sensor and carbon dioxide sensor control of Variable Air Volume (VAV) boxes and ventilation strategies, as well as variable frequency drives and air transfer fans.

For the sake of this impact analysis, strategies that were not required per the relevant energy code were assumed to be correctly modeled. Savings from these strategies represent a relatively small portion of the overall program savings.

The formulas that KEMA used to recalculate or adjust the savings for each strategy that had a numeric baseline value are shown in the next section, with definitions for each variable.

4.1.3 Determination of Strategy Baselines

After reviewing all sample documents it was evident that the design engineers consistently utilized what they understood to be prevailing energy code values for their baseline conditions. Several of the strategies applied were not addressed by the energy codes, with the understanding that they were not required. For these, the baseline condition was “not installed”, a non-numeric condition.

Savings for strategies that have a numeric baseline condition may depend heavily on that numeric value. Therefore, if the standard (i.e. non-participant) design or construction practices differ from energy code values, the actual impacts for the EDA program will be different from those calculated.

Measurement of the actual baseline construction practices was an initial requirement of this study, but Xcel Energy and KEMA subsequently recognized this to be a very difficult task to accomplish with high precision and great detail. In Colorado the guiding document is “Energy Baseline Modeling Protocol – Colorado Version 1.0”, dated January 15, 2007. This required

that the baseline conditions for modeling a building be governed by the minimum requirements of the IECC 2003 Energy Code, using the ASHRAE 90.1-2001 compliance path.

Although specific numeric baseline values for many strategies are clearly defined in these documents, others were not so clearly defined, or may not have been defined at all. Still others required some interpretations of the code listed parameters to apply to what may have been similar but unlisted situations. Furthermore, the compliance path chosen may have been a non-prescriptive path with limited trade-offs between certain compliance features, thus complicating an interpretation of the EDA guideline base requirements for the measures involved in the trade-off.

Given that every attempt to comply with the prevailing energy code standards may have been undertaken during the design phase of a building project, sometimes design changes are decided later in the process that may affect the baseline standards. As a result, the building may not be constructed exactly as planned, and the EDA baseline conditions may not be fully met.

Finally, unlikely as it may be, construction delays and costs sometimes force contractors to install less expensive or more readily available equipment, materials and labor practices than the design documents specify. Sometimes, but less frequently, conditions work out the other way, leading to more efficient buildings or building components. In either case, the actual baseline conditions may be different from those specified during the design process.

The presence of so many variables across two states with large Xcel Energy service areas led KEMA to devise a modified Delphi approach to quantify the average deviations from the energy code standards that typical C&I buildings and major retrofits are actually applying. The intent was to enlist 15 C&I design professionals throughout the Xcel Energy service areas of both states to participate in a type of on-line “think tank” and share their observations and experiences regarding standard construction practice. The ideal group would consist of five engineers, five architects and five building contractors.

Xcel Energy furnished a list of over 300 professionals with contact information, and KEMA sent invitations to all of these to participate, offering them a gift of \$100 for their cooperation. About 200 of these had current e-mail addresses with companies still in business, and a total of 15 of those responded to KEMA invitation to participate; one of these, however, did not qualify.

To each of the 14 respondents that qualified, KEMA sent a spreadsheet with a list of 11 strategies to rank according to an energy code reference. They were asked to indicate whether, in their experience, most buildings were being built at code standards or whether they were being constructed 5%, 10% or 25% better than code; or, 5%, 10% or 25% worse than code. Figure 1 shows an example of the first Delphi form that was sent.

Figure 1: Sample Delphi Form

Xcel Energy Energy Design Assistance Program									
Initial inputs from each Delphi Participant.									
Item No.	Item Definition	Units or Values of Comparison	Not as Good as Code			Energy Code is Always Used	Better Than Code		
			25% Below Used More Often	10% Below Used More Often	5% Below Used More Often		5% Above Used More Often	10% Above Used More Often	25% Above Used More Often
1	Roof insulation	R-value							
2	Wall insulation	R-value							
3	Glazing Uo	Whole unit							
4	Glazing SHGC	Whole unit							
5	Interior Lighting density	Watts/SqFt							
6	Interior Lighting level	Foot Candles							
7	Motors 5 to 15 horsepower	Efficiency							
8	Motors over 15 horsepower	Efficiency							
9	Space Cooling equipment	Efficiency							
10	Space Heating equipment	Efficiency							
11	Domestic Hot Water equipment	Efficiency							

Notes:

- 1 This study applies only to large commercial and industrial new construction or major retrofits.
- 2 This includes large dormitories, large apartments, and condominium buildings, with 50 or more units.
- 3 Please focus on what has actually been constructed over the last three years, not what was designed or specified.
- 4 Do not judge solely by what your firm uses, but strive to capture the average or typical practice throughout your region.
- 5 Think in terms of what you have observed in practice, not what is politically correct. We need unbiased opinions.
- 6 After the initial inputs are averaged from all 15 participants, you will be copied on the results.
- 7 Then you may modify your initial responses based on the collective opinion, or you may explain why you believe your initial responses are correct. It could be a regional difference, for example.
- 8 After the second set of inputs with possible modifications have been received, the new responses will be weighted and averaged again.
- 9 Then you will be copied on the final results.
- 10 Your individual names, responses, etc. will not leave this (KEMA) office. Not even Xcel Energy will be allowed to know your responses to this survey.

A total of 13 participants responded with their opinions, and their responses were averaged to obtain a first estimate for each strategy. The next table shows their responses and the strategy averages. At this point, they indicated, as a group, that all 11 strategies on average are being installed above code.

For the final round of the Delphi approach, each participant was sent a copy of the table, but with a highlight of his/her original responses, with a new row for him/her to alter those responses if desired. It was re-emphasized to them to dismiss all projects that they might have done under the influence of the EDA program, and to consider only those projects outside of EDA influence.

The current analysis (Figure 2, below) shows the impact evaluation results without any adjustments for the baseline conditions. When the final Delphi results were received and processed, the average of those values was used to adjust the baseline conditions for every applicable strategy in each project, and the results of those adjustments were used to determine the final EDA program gross evaluation results.

Figure 2: Final Delphi Analysis

#	Ave of Code Usage Perspective	Roof insul.	Wall insul.	Glazing Uo	Glazing SHGC	Interior Lighting density	Interior Lighting level	Motors 5 to 15 HP	Motors over 15 HP	Space Cooling equip.	Space Heating equip.	Dom. Hot Water equip.
1	5.9%	5%	0%	15%	15%	5%	0%	5%	5%	5%	5%	5%
2	5.9%	5%	10%	10%	10%	5%	0%	0%	0%	10%	10%	5%
3	1.4%	5%	5%	5%	5%	0%	-5%	0%	0%	0%	0%	0%
4	3.2%	5%	0%	5%	5%	10%	5%	0%	0%	0%	5%	0%
5	4.5%	5%	10%	5%	5%	0%	0%	5%	5%	5%	5%	5%
6	4.1%	10%	5%	5%	5%	0%	5%	0%	0%	5%	10%	0%
7	3.2%	0%	5%	-5%	10%	10%	10%	0%	5%	-10%	5%	5%
8	5.9%	5%	5%	0%	0%	10%	5%	10%	5%	5%	10%	10%
9	4.5%	10%	5%	10%	10%	0%	0%	0%	5%	0%	10%	0%
10	-0.9%	0%	0%	0%	0%	-5%	-5%	0%	0%	0%	0%	0%
11	3.7%	10%	5%	3%	3%	0%	0%	5%	5%	0%	5%	5%
12	1.8%	5%	0%	0%	0%	0%	0%	5%	5%	0%	0%	5%
13	5.5%	5%	5%	0%	5%	0%	0%	10%	10%	10%	10%	5%
Avg	3.6%	5.4%	4.2%	3.2%	5.5%	2.7%	1.2%	3.1%	3.5%	1.4%	5.8%	3.5%

Careful interpretation of the two “Motors” results must be made. Since the differences in efficiencies between standard and premium efficiency motors are slight, on the order of one or two percent, the responses must be interpreted to indicate the percentages of installed motors that exceed the code motor efficiencies. In most applications the energy codes do not specify the application of premium efficiency motors, so the baselines are simply standard motor efficiencies.

4.1.4 Recalculation Formulas

The strategies that could be adjusted in terms of savings were those that utilized a code baseline condition, a design condition, and a verified retrofit condition. If it was found that any of these variables changed, KEMA utilized the new values to adjust the savings, based on the

original savings calculated for that strategy by DOE2 during the early exploratory (i.e. the “strategy”) phase of the process, or else if modified later and subsequently documented.

This adjustment process assumed that the original savings calculated from the DOE2 model was correct for the original set of conditions. Without access to the DOE2 input files, there was no basis for assuming otherwise. If any of the conditions changed from the original set, KEMA made adjustments by applying ratios involving those changes to the original savings. After the appropriate adjustments to the original savings were made for each strategy, the strategy savings were summed for the project and compared to the tracking savings, the design savings and the Xcel Energy verified savings. In 75% of the project the verified savings were within 10% the tracking savings.

The formulas derived and utilized in this study are detailed from Figure 3 to Figure 21. Similar formulas were applied to adjust the natural gas savings.

Figure 3: Insulation formula

Strategy Measure : Insulation

$$Correct\ kWh\ Savings = (KWH_{sav})(\%_{comp}) \left(\frac{\frac{1}{R_{cor}} - \frac{1}{R_v}}{\frac{1}{R_b} - \frac{1}{R_r}} \right)$$

Where :

- KWH_{sav} = Design kWh Savings
- %_{comp} = Percent Complete
- R_{cor} = Corrected Baseline R – Value
- R_v = Verified R – Value
- R_b = Design Baseline R – Value
- R_r = Design Retrofit R – Value

Figure 4: Glazing formula

Strategy Measure : Glazing

$$Correct\ kWh\ Savings = (KWH_{uo}) \left(\frac{UO_{cor} - UO_v}{UO_b - UO_r} \right) + (KWH_{sc}) \left(\frac{SC_{cor} - SC_v}{SC_b - SC_r} \right)$$

Where :

- KWH_{uo} = U - Factor Design kWh Savings
- UO_{cor} = Corrected Baseline U - Factor
- UO_v = Verified U - Factor
- UO_b = Design Baseline U - Factor
- UO_r = Design Retrofit U - Factor
- KWH_{sc} = Solar Heat Gain Coefficient (SHGC) Design kWh Savings
- SC_{cor} = Corrected Baseline SHGC
- SC_v = Verified SHGC
- SC_b = Design Baseline SHGC
- SC_r = Design Retrofit SHGC

Figure 5: Lighting formula

Strategy Measure : Lighting

$$\text{Correct kWh Savings} = \left(\frac{KWH_{sav}}{\%_{comp}} \right) \left(\frac{PD_{cor} - PD_v}{PD_b - PD_r} \right)$$

Where :

- KWH_{sav} = Design kWh Savings
- %_{comp} = Percent Complete
- PD_{cor} = Corrected Baseline Power Density (W/sq ft)
- PD_v = Verified Power Density (W/sq ft)
- PD_b = Design Baseline Power Density (W/sq ft)
- PD_r = Design Retrofit Power Density (W/sq ft)

Figure 6: Lighting controls formula

Strategy Measure : Lighting Controls

$$\text{Correct kWh Savings} = (KWH_{sav}) \left(\frac{SF_v}{SF_r} \right)$$

Where :

- KWH_{sav} = Design kWh Savings
- SF_v = Verified Square Foot
- SF_r = Design Retrofit Square Foot

Figure 7: Cooling formula

Strategy Measure : Cooling EER

$$\text{Correct kWh Savings} = (KWH_{sav}) \left(\frac{\frac{1}{EER_{cor}} - \frac{1}{EER_v}}{\frac{1}{EER_b} - \frac{1}{EER_r}} \right)$$

Where :

- KWH_{sav} = Design kWh Savings
- EER_{cor} = Corrected Baseline EER
- EER_v = Verified EER
- EER_b = Design Baseline EER
- EER_r = Design Retrofit EER

Figure 8: High performance space cooling formula

Strategy Measure : HP Space Cooling

$$\text{Correct kWh Savings} = (KWH_{sav}) \left(\frac{\frac{1}{EER_{cor}} - \frac{1}{EER_v}}{\frac{1}{EER_b} - \frac{1}{EER_r}} \right)$$

Where :

- KWH_{sav} = Design kWh Savings
- EER_{cor} = Corrected Baseline EER
- EER_v = Verified EER
- EER_b = Design Baseline EER
- EER_r = Design Retrofit EER

Figure 9: Cooling kW/Ton formula

Strategy Measure : Cooling kW/Ton

$$Correct\ kWh\ Savings = KWH_{sav} \left(\frac{KWTON_{cor} \cdot KWTON_v}{KWTON_b \cdot KWTON_r} \right)$$

Where :

- KWH_{sav} = Design kWh Savings
- KWTON_{cor} = Corrected Baseline kW/ Ton
- KWTON_v = Verified kW/ Ton
- KWTON_b = Design Baseline kW/ Ton
- KWTON_r = Design Retrofit kW/ Ton

Figure 10: Space heating

Strategy Measure : Space Heating

$$Correct\ kWh\ Savings = (KWH_{sav}) \left(\frac{EFF_{cor} - EFF_v}{EFF_b - EFF_r} \right)$$

Where :

- KWH_{sav} = Design kWh Savings
- EFF_{cor} = Corrected Baseline Efficiency
- EFF_v = Verified Efficiency
- EFF_b = Design Baseline Efficiency
- EFF_r = Design Retrofit Efficiency

Figure 11: High performance space heating formula

Strategy Measure : Space Heating

$$Correct\ kWh\ Savings = KWH_{sav} \left(\frac{\frac{1}{COP_{cor}} - \frac{1}{COP_v}}{\frac{1}{COP_b} - \frac{1}{COP_r}} \right)$$

Where :

- KWH_{sav} = Design kWh Savings
- COP_{cor} = Corrected Baseline Coefficient of Performance
- COP_v = Verified Coefficient of Performance
- COP_b = Design Baseline Coefficient of Performance
- COP_r = Design Retrofit Coefficient of Performance

Figure 12: Premium motors formula

Category	Measure	Premium	Efficiency	Motors
Correct kWh Savings	KWH_{sav}			$\left(\frac{MEFF_{cor} - MEFF_v}{MEFF_b - MEFF_r} \right)$
Where :				
KWH _{sav} = Design kWh Savings				
MEFF _{cor} = Corrected Baseline Motor Efficiency				
MEFF _v = Verified Motor Efficiency				
MEFF _b = Design Baseline Motor Efficiency				
MEFF _r = Design Retrofit Motor Efficiency				

Figure 13: Heat recovery formula

Category	Measure	Latent	Recovery
Correct kWh Savings	KWH_{sav}	$\left(SEN_p \left(\frac{\%SEN_v}{\%SEN_d} \right) + LAT_p \left(\frac{\%LAT_v}{\%LAT_d} \right) \right)$	
Where :			
KWH _{sav} = Design kWh Savings			
SEN _p = Sensible Heat Recovery Factor			
%SEN _v = Verified % of Sensible Heat Recovery			
%SEN _d = Design % of Sensible Heat Recovery			
LAT _p = Latent Heat Recovery Factor			
%LAT _v = Verified % of Latent Heat Recovery			
%LAT _d = Design % of Latent Heat Recovery			

Figure 14: Appliances formula

Category	Measure	Appliances
Correct kWh Savings	(KWH_{sav})	$\left(\frac{EF_{cor} - EF_v}{EF_b - EF_r} \right)$
Where :		
KWH _{sav} = Design kWh Savings		
EF _{cor} = Corrected Baseline Energy Factor		
EF _v = Verified Energy Factor		
EF _b = Design Baseline Energy Factor		
EF _r = Design Retrofit Energy Factor		

Figure 15: Low flow devices formula

Category	Measure	Low Flow Devices
Correct kWh Savings	kWh_{sav}	$\left(\frac{\text{GPM}_{cor} \text{GPM}_v}{\text{GPM}_b \text{GPM}_r} \right)$
Where :		
kWh _{sav} = Design kWh Savings		
GPM _{cor} = Corrected Baseline Gallons Per Minute		
GPM _v = Verified Gallons Per Minute		
GPM _b = Design Baseline Gallons Per Minute		
GPM _r = Design Retrofit Gallons Per Minute		

Figure 16: Domestic hot water formula

Category	Measure	Domestic Hot Water (DHW)
Correct kWh Savings	kWh_{sav}	$\left(\frac{\text{DHW}_{cor} \text{DHW}_v}{\text{DHW}_b \text{DHW}_r} \right)$
Where :		
kWh _{sav} = Design kWh Savings		
DHW _{cor} = Corrected Baseline DHW Efficiency		
DHW _v = Verified DHW Efficiency		
DHW _b = Design Baseline DHW Efficiency		
DHW _r = Design Retrofit DHW Efficiency		

Figure 17: Occupancy sensor formula

Category	Measure	Occupancy Sensor Control
KEMA kWh Savings	= Verified kWh Savings	

Figure 18: Carbon monoxide sensor formula

Category	Measure	Carbon Monoxide Sensors
KEMA kWh Savings	= Verified kWh Savings	

Figure 19: Carbon dioxide sensor formula

Category	Measure	Carbon Dioxide Sensors
KEMA kWh Savings	= Verified kWh Savings	

Figure 20: Variable frequency drive formula

Category	Measure	Variable	Frequency	Units
<i>KEMA kWh Savings = Verified kWh Savings</i>				

Figure 21: Ventilation formula

Category	Measure	Ventilation
<i>KEMA kWh Savings = Verified kWh Savings</i>		

4.2 Findings

The analytical impact scope of this study included 28 EDA projects completed in 2007, 2008 and 2009, i.e. those listed in the participant tables. It is probable that other projects have been completed since the documents for this project were obtained. These results, therefore, represent only those 28 projects.

Total tracking system savings for the 28 Colorado projects are 17,400,015 kWh, whereas the weighted total from the sample of 12 are 17,225,789 kWh, indicating a mean bias error (MBE) of -1.0%. These numbers are shown in Table 5 (next table, below) which also shows the actual and weighted sample square feet, marketing kW reductions, natural gas savings in MCF, and incentive dollars paid. The table breaks out these metrics by sector, as listed in the tracking data.

The project sampling variable was “Marketing kWh”, and the sample obviously represents this very well. It also does acceptably well with the other two impact metrics, “Marketing kW” and “MCF” overall, as shown on the last line of the lower sub-table. The sample does not capture a representative proportion of the building square feet, suggesting that the correlation between kWh savings and building area is not very strong. On the other hand, it is apparent by the relatively low sampling bias in the “Sum of Total Incentive” column that the incentives paid are meaningfully correlated to kWh savings. The same may be said of the “Sum of Marketing kW”.



Table 5: EDA Program Data – Colorado

Sampling Statistics for Colorado						
Sector for State of Colorado, All Projects	Sum of Total Square feet	Sum of Marketing kW	Sum of Marketing kWh	Sum of MCF	Sum of Total Incentive	Pop. Count
Arts, Entertainment, and Recreation	59,773	107	136,112	0	\$ 19,099	1
Commercial Office	1,242,422	535	2,116,210	0	\$ 117,979	6
Education Services	826,643	1,077	2,999,272	0	\$ 179,525	8
Housing	474,300	286	917,293	0	\$ 48,620	3
Retail Trade	1,356,409	2,142	11,231,128	0	\$ 428,742	10
Totals for CO	3,959,547	4,147	17,400,015	0	\$ 793,965	28
Sector for State of Colorado, Sample Projects	Sum of Total Square feet	Sum of Marketing kW	Sum of Marketing kWh	Sum of MCF	Sum of Total Incentive	Samp. Count
Arts, Entertainment, and Recreation	0	0	0	0	\$ -	0
Commercial Office	76,220	56	281,167	0	\$ 15,229	1
Education Services	185,425	428	1,367,790	0	\$ 48,322	3
Housing	85,000	40	133,958	0	\$ 6,800	1
Retail Trade	1,050,053	1,634	8,935,507	0	\$ 330,061	7
Weighted Totals for CO	2,504,444	3,626	17,225,789	0	\$ 661,023	12
Sampling Bias for CO	-36.7%	-12.6%	-1.0%	0.0%	-16.7%	

Table 6, next page, contains individual project results for the Colorado sample, comparing the KEMA adjusted savings to the tracking system savings. The center column shows the Final Sample Weights for these projects, and the next six columns show the weighted totals for the KEMA results and the tracking results.

Table 6: Savings Analyses – Colorado

Colorado Sample											MBE: -1.00%						
No.	KEMA Project Savings			Tracking Project Savings			Project Realization Rate				Final Sample Weight	KEMA Program Savings			Tracking Program Savings		
	Demand kW	Electric Energy kWh	Natural Gas MMBTU	Demand kW	Electric Energy kWh	Natural Gas MMBTU	Demand kW	Electric Energy kWh	Natural Gas MMBTU	Demand kW		Electric Energy kWh	Natural Gas MMBTU	Demand kW	Electric Energy kWh	Natural Gas MMBTU	
1	210.2	781,199	0	262.0	973,675	0	0.80	0.80		2.00	420.4	1,562,398	0	524.0	1,947,350	0	
2	252.5	1,235,902	154	238.0	1,164,872	0	1.06	1.06		2.00	505.0	2,471,804	308	476.0	2,329,744	0	
3	38.0	127,325	706	40.0	133,958	0	0.95	0.95		3.00	114.1	381,974	2118	120.0	401,874	0	
4	165.4	635,515	119	158.0	607,085	0	1.05	1.05		3.00	496.2	1,906,545	358	474.0	1,821,255	0	
5	108.1	487,144	-94	108.0	486,918	0	1.00	1.00		3.00	324.2	1,461,433	-283	324.0	1,460,754	0	
6	107.4	222,494	945	81.0	167,809	0	1.33	1.33		3.00	322.2	667,483	2836	243.0	503,427	0	
7	91.3	243,147	726	85.0	226,306	0	1.07	1.07		3.00	274.0	729,442	2179	255.0	678,918	0	
8	214.2	1,102,323	2,203	209.0	1,075,744	0	1.02	1.02		1.00	214.2	1,102,323	2203	209.0	1,075,744	0	
9	370.5	2,392,990	-1,135	329.0	2,124,977	0	1.13	1.13		1.00	370.5	2,392,990	-1135	329.0	2,124,977	0	
10	60.4	303,434	10	56.0	281,167	0	1.08	1.08		5.00	302.2	1,517,169	50	280.0	1,405,835	0	
11	330.8	1,943,321	96	334.0	1,962,005	0	0.99	0.99		1.00	330.8	1,943,321	96	334.0	1,962,005	0	
12	265.6	1,558,646	920	258.0	1,513,906	0	1.03	1.03		1.00	265.6	1,558,646	920	258.0	1,513,906	0	
Expanded Program Savings:											3,979	17,874,505	9,747	3,865	17,400,015	0	

The “Expanded Program Savings” on the bottom row are simply the sums of the weighted project savings divided by 1 + MBE. The expanded savings for the tracking “Electric Energy kWh” column agrees exactly with the tracking total savings for all projects, indicating that the sample weights are all valid.

The KEMA “Electric Energy kWh” column sums to 17,874,505 kWh after adjusting for the MBE. This result, considered to be the “True” total program gross savings for Colorado, divided by the tracking total savings, is known as the “Realization Ratio”. The value of this ratio is 1.03, indicating that the actual gross program savings are 3% greater than the savings reported by the tracking data.

The actual gross program electric demand savings are 3,979 kW, according to the KEMA evaluation. The indicated natural gas savings, as calculated by KEMA, are 9,747 MCF, which are attributable to other gas companies serving those customers.

4.3 Net-To-Gross Assessment

A calculation with the KEMA free-rider NTG protocol yielded a ratio of 65.8% overall. This calculation was completed with a 90% confidence level and a 10.2% relative precision of error. The spillover analysis yielded a 13.2% spillover rate, suggesting that the combined NTG ratio is 79.1% for the EDA program.

By current standards, 70% is a high NTG ratio because the ratios for most programs have been steadily declining over the last two decades as more public emphasis and education are created by conservation programs. Prescriptive measure oriented conservation programs must regularly increase their baseline standards to stay ahead of rapidly changing energy codes and market level efficiencies. The EDA program is not as dependent on specific fixed baseline efficiencies because it naturally tracks and stays above energy code minimum standards. This fact, combined with the fact that the program has not been in operation very long, tends to minimize free-ridership, thus increasing the NTG ratio.

Per an Xcel Energy request, KEMA made a company-wide assessment of similar program evaluations. KEMA performed many of these evaluations in 2005 in the Northeast and California, and has recently completed another major C/I program evaluation in California. An initial review of NTG from these evaluations shows that the EDA program ratio is similar to those of other commercial/industrial new construction programs, which are listed in the table below. They average 71.4%, but they are net of free-riders only, and do not include spillover

which was not calculated as part of those studies. This average compares reasonably well with the reported 65.8% NTG.

Table 7: Initial review – similar program NTG ratios

Program	Sector	Year	NTG Ratio
1	C	2005	74.0%
2	I	2005	65.0%
3	C&I	2005	73.5%
4	C&I	2005	70.6%
5	C&I	2005	81.9%
6	C&I	2008	63.4%

The six programs shown in the table were all conducted by KEMA engineers in 2005 and 2008, all in California. Although KEMA has conducted numerous conservation program NTG studies, these were the only programs that were similar enough to the Xcel Energy EDA program to offer a valid comparison.

5. Conclusions and Recommendations

5.1 Conclusions

The scope of this evaluation included the entire program as of September of 2009, at which time there had been 28 projects completed, documented and recorded in a program tracking database. To manage evaluation costs, a representative sample of projects was calculated to achieve a statistical precision of +/- 10% or better at a 90% confidence level. This sampling target precision was more than met after it became feasible to hand-pick a few sample projects.

The gross electric demand and energy savings and natural gas savings are higher than the program savings recorded in the project tracking system. There appeared to be no systematic reason for the difference.

This difference in electric energy and demand, expressed as a “Realization Ratio”, is 1.03 for Colorado. The highest realization ratio found was 1.33, and the lowest was 0.80, each occurring only once.

The program NTG ratio was determined for the Colorado program to be 79.1%. The free-rider adjustment yielded a 65.8% NTG ratio, and the spillover effect added 13.2% to that. This was determined by a 90% confidence level and a 10.2% relative precision of error. The fact that this is a program serving the commercial and industrial new construction marketplace suggests that freedrivers (also known as non-participant spillover) will not be significant enough to merit additional evaluation costs; and, any effects of this are partially addressed in the participant spillover assessment.

The EDA program has a final verification process which determines gross savings. This final verification process requires a detailed site inspection to verify the presence and completeness of all the chosen design strategies after the buildings have been built and have begun to be utilized. If it is found that any strategy could not be fully verified or was not installed as designed, appropriate adjustments to the savings are made before the final savings and rebates are calculated. The gross realization ratio of greater than 100% suggests that the tracking estimates tend to be slightly conservative.

Net program savings that may be attributed to the direct effects of the EDA program are 81.3% of the gross impacts calculated in this study. Particularly, these net savings, after adjusting for free-rider losses and spillover gains, become 14,531,972 kWh, 3,235 kW and 7,924 MCF.

5.2 Recommendations

A more accurate impact evaluation of the EDA will be possible in the future if more of the detailed engineering design documentation were obtainable. In particular, most of the energy and demand impact estimates were calculated using the hourly building energy simulation code known as DOE2. Currently the results of those computer models are included in the documentation that is delivered to Xcel Energy. Unfortunately, however, much design information and some important assumptions were utilized in the DOE2 models but not included in the documentation.

Therefore, KEMA recommends that Xcel Energy begin to request the final DOE2 design input files, fully defined and documented so that an evaluator will be able to see the detailed information and assumptions utilized for each strategy.

Another evaluation problem occurs when strategy choices are altered late in the design process or during construction, and the DOE2 models are not rerun to recalculate savings for those changes. If the impact evaluator had access to the DOE2 input files, they could then be utilized to post-calculate the savings by such “last minute” changes. In 2009 Xcel Energy implemented this strategy, known as “as-built” or “as-verified” modeling, for projects meeting a certain criterion.

KEMA recommends that Xcel Energy apply a simple “true-up” of the tracking system for existing projects by multiplying each estimate by the realization ratio of 1.03 before formally reporting the impacts. For many programs this is also applied to future projects, but KEMA does not recommend this, because this is the first program evaluation, and there were no systematic errors found in the tracking estimates or the approach applied. It is probable that the current realization ratio will not be the same for the next group of projects. On the other hand, if a positive (greater than unity) realization ratio is found with the next project evaluation the average of the two may be applied to future projects with more confidence.

KEMA’s free-rider NTG protocol yielded a ratio of 65.8% overall. The spillover analysis yielded a 13.2% spillover rate. KEMA recommends a combined NTG ratio of 79.1% for the EDA program. When this is combined with the realization ratio of 1.03, the overall program net savings is about 81% of the tracking estimate.