Discrepancy, What Discrepancy?
Reasons for the Difference between Claimed and Evaluated Savings

Al Lutz and Phanindra Pagadala, Itron, Inc.

ABSTRACT

Program cycle-to-program cycle, evaluators find a discrepancy between claimed savings from energy efficiency programs and their verified savings. These differences are caused by a number of factors, but which are most important? Which reasons for discrepancy affect the claimed energy savings to a large degree, to a smaller degree, and in which direction? The recent 2010 to 2012 California IOU (investor owned utility) custom impact evaluation involved the analysis of over 400 energy efficiency projects, including gross impact evaluation of savings claims, representing the IOU-wide custom portfolio. This paper quantifies the energy impact of the main reasons for discrepancy that were found from the evaluation's commercial building energy efficiency measures, disaggregated by measure type for greater insights into trends by energy efficiency project. In evaluating the gross energy savings claims, we found that the discrepancy for each project could be due to a number of factors, including, for example, eligibility requirements, changes in operating hours, or the applicable baseline. By investigating and quantifying the reasons for the discrepancy, the evaluation community will assist the IOUs and their implementers in better assessing projects as they are being developed with respect to the highest risk factors. The expectation that the evaluated savings will better match the claimed savings, at least for factors the IOUs can control, will improve the effectiveness of custom programs in any jurisdiction where they are in use.

Introduction

The evaluation of energy efficiency programs serves an important regulatory and advisory function. Evaluation reports will generally provide a final realization rate for a program (or a portfolio of programs) and offer recommendations to increase program effectiveness. A deeper investigation into the reasons for discrepancies between claimed and evaluated savings, through careful standardized analysis of project results, and the reasons behind these results, can be used to inform the evaluation effort and minimize future discrepancies. To truly understand energy efficiency project performance, we investigate the discrepancy factors leading to that performance. This is particularly important for custom programs and markets, given the wide variability in measures types and project size. Custom projects are among the largest projects in an IOU's energy efficiency portfolio. Understanding energy performance for custom projects from an evaluation perspective is important in improving project and program performance, and in meeting portfolio goals. The diversity of measures and programs across different subsectors, along with the multiple project drivers and market actors, make this investigation into discrepancy factors particularly important and instructive in determining what aspects of program design and project implementation to concentrate on when developing programs and projects – and when claiming and verifying energy savings. By considering the effects of discrepancy factors, both overall and by measure type, the utilities and their implementers can identify and act on areas for improvement and ways to reduce the discrepancies in the claimed and evaluated savings, achieving realization rates closer to unity.

Eight discrepancy factors and seven measure groups are included in this analysis. A number of charts were constructed among factors and groups to facilitate comparison. The effects of the discrepancy factors on all commercial projects is shown first. Following this, charts showing the effects of the discrepancy factors on measure groups are displayed.

The custom impact evaluation report authorized by the California Public Utility Commission (CPUC) Energy Division (ED) for the 2010-2012 evaluation cycle (Itron et al. 2013) is the source of data used in this analysis. This evaluation report is publicly available at www.calmac.org. The evaluation effort involved site-specific gross impact activities for 429 custom energy efficiency projects for the commercial, agricultural and industrial sectors. This paper focuses on the 157 commercial sector projects in that sample and measure groups relevant to that sector. Each project was evaluated and a reason for the discrepancy (and the percentage of the discrepancy) was provided by the evaluating engineer. For some projects, more than one reason was cited. When there was more than one factor, the discrepancy was allocated between factors. Discrepancies were explained in detail in the final site report for each energy efficiency project. By designing the evaluation to capture that information at the outset, the collection of discrepancy determinations and the percentages allocated to each factor was greatly facilitated.

It is important to realize that there are both gross impact and net impact components. These components lead to gross realization rates, net to gross ratios, and net realization rates combining those factors. This paper addresses the gross energy savings and gross realization rate; discrepancies causing net impact differences have not been addressed. Gross realization rates, ex-post gross savings divided by ex-ante savings claimed, were calculated and are shown in this paper for different measure types based on site-specific energy project realization rates.

Description of Discrepancy Factors

The evaluation identified eight important discrepancy factors leading to adjustments to the ex-ante claims stemming from ex-post gross impact estimates in the M&V sample. The eight factors are: operating conditions, inappropriate baseline, calculation method, ineligible measure, equipment specification, tracking database discrepancy, program rule compliance, and unquantified fuel impacts.[1] These factors are described in more detail in this section.

- Differences in operating conditions (for example, hours of operation, VSD speeds, reversions to original operation, temperature setpoints that changed from the forecast setpoint, operations based on forecasts instead of the most current observed / measured conditions, changed production levels due to market conditions, etc.)
- Inappropriate baselines or baseline conditions used for ex-ante savings estimation (for example, rejected early (or normal) replacement claims, new equipment that do not exceed code-required efficiency levels, new equipment that do not exceed industry standard efficiency levels, inaccurate baseline or pre-retrofit operating hours, etc.)
- Calculation methods used for ex-post savings estimation were revised from those used to estimate ex-ante savings (for example, simulation models that utilize Title 24 compliance schedules as opposed to actual building operation; switching from Energy Pro to eQuest

[1] Uninstalled measures, measure count variations, and inoperable measures were investigated at a project level but not found to be significant discrepancy factors.

building simulation software; use of or different weather normalization techniques or weather files; different spreadsheet calculation approaches based on post-retrofit or post-construction data availability; expanded spreadsheet approaches to account for varying versus constant loads, different resolution, and interactive effects; shifts to or from the use of billing analyses and interval data, particularly for peak demand impacts; use of calculation inputs defining initial or ex-post operating conditions; etc.)

- Ineligible measures (measures or repairs not allowed by program rules or a replacement of an existing system with a system with identical performance).
- Equipment specifications (changes from the final ex-ante estimates to the actual equipment installed in the field as verified by the evaluators)
- Tracking database discrepancies (errors based on clear project documentation or duplication, as when ex-ante savings calculation results from project documentation do not match the final claimed ex-ante savings as reported in utility tracking data)
- Program rule compliance (program rule violation that does not involve ineligible measures)
- Unquantified fuel impacts (the analysis did not consider all fuel impacts; projects may involve electric HVAC measures that have thermal effects and projects where cogeneration systems are a source of electrical and thermal energy)

Measure Group Definition

Seven measure groups were selected based on the frequency on which they occurred in the custom sample. Projects were generally grouped into the primary measure type which accounted for the majority of savings; the exception is the whole building group which generally covered a range of measures in an individual project. The measure groups studied are as follows:

- Chillers – any new or rehabilitated water-cooled or air-cooled chillers, and associated cooling towers
- Boilers - new or upgraded boilers and their ancillary systems, including boiler controls
- HVAC Controls – includes sensors, control equipment, and EMS systems
- HVAC Other – includes air handling units, economizers, fans, and pumps
- Variable Speed Drives – any variable speed drive controlling motors (usually HVAC motors)
- Commissioning / Retro-commissioning – adjustments to new or existing control systems
- Whole Building Projects – comprehensive packages of energy efficiency measures, typically in new construction projects that utilize building simulation models such as Energy Pro

Overall and Measure Specific Discrepancy Factors Explaining the Gap between the Claimed and Evaluated Savings

Gross realization rates are presented for all evaluated commercial projects and for the measure groups in Table 1. The realization rates were calculated as an un-weighted simple average of the site specific project gross realization rates (including and excluding points with extreme gross realization rates higher than 250% and lower than -50%).[2] These realization rates can be compared to previous studies which investigated very similar measure groups (Lutz and Tirumalashetty, 2012) and programs with an exclusive focus on these groups. Table 1 indicates that some groups are relatively high performers, namely boilers and chillers, whereas other groups are low performers (VSDs, HVAC Controls, and Commissioning projects).

Table 1. Gross realization rates by measure groups

Measure Group	Median GRR	Mean GRR (excludes Extreme Points)	Mean GRR (All Points)	N
All - Commercial Projects (kWh)	0.52	0.58	0.72	157
Boilers (therms)	0.88	0.87	0.87	6
Chillers (kWh)	0.63	0.73	0.86	15
HVAC Other (kWh)	0.66	0.58	1.21	21
HVAC Controls (kWh)	0.45	0.47	0.47	29
Commissioning (kWh)	0.41	0.39	0.39	9
Variable Speed Drives (kWh)	0.38	0.46	0.61	14
Whole Building (kWh)	0.69	0.68	0.61	19

Source: Itron, et.al. 2014.

In order to find the frequency and the magnitude of the discrepancies for each discrepancy factor for the measure groups, each project was assigned a measure group and a primary factor. Some projects, especially those involving multiple measures (such as whole building projects), but also for single-measure projects, were assigned a secondary factor. The percentage estimate represents the percent decrease (above the zero axis) or percent increase (below the zero axis) of actual savings as compared to the ex-ante savings claim. Thus, if there is only one factor, the percent would be the GRR minus one. The projects, their primary and secondary discrepancy factors, and the relevant percentages were tabulated to allow grouping and data analysis. The actual energy increase or decrease is calculated by combining the product of the percentages for primary and secondary factors and the ex-ante savings claims for kWh and therms. As may be expected, primary factors may have caused a decrease from ex-ante savings and the secondary factor may have caused an increase from ex-ante savings – or vice versa. In the majority of cases however, the factors tended to reinforce the increase or decrease in the realization rate.

Figure 1 shows the discrepancy factors as they affect the total claims for all commercial projects. Clearly, baseline determinations and operating conditions appear very significant. Of note, changed baseline determination decreases evaluated savings for therms, while increasing savings for kWh. Changed operating conditions result in decreased evaluated savings for both therms and kWh.

IOU reviewers and their implementers should, together with program participants, pay careful attention, both during project acceptance and project review before claims are finalized, that baselines are correctly identified as the least efficient technically capable alternative and that the baseline type – particularly early retirement or normal replacement/replace on burnout – is claimed correctly (ALJ 2011). In addition, as a quality control process during project review,

[2] The unweighted average of project realization rates was used as a metric of measure performance, since the sample was designed around individual utilities and fuel types, and not around measure groups.

operating conditions should be revisited and savings adjusted to reflect stabilized, current actual parameters, such as hours of operation, power draw, number of current occupants, and HVAC equipment schedules. The use of actual (versus forecast) operating conditions is vitally important, as verified savings claims are based upon conditions found at the time of the evaluation. Expanded post-installation M&V activities and documentation by the IOUs before claims are finalized can allow better representation of actual operating conditions. Modifying IOU measure-specific post-installation forms and reviewer checklists to include explicit indications of changed parameters and adjusted savings for all custom projects are possible steps to ensure savings are updated with the most current information. In short, IOUs should not treat savings claims as final until installation is fully complete, systems tested and commissioned, and stable operation has been achieved.

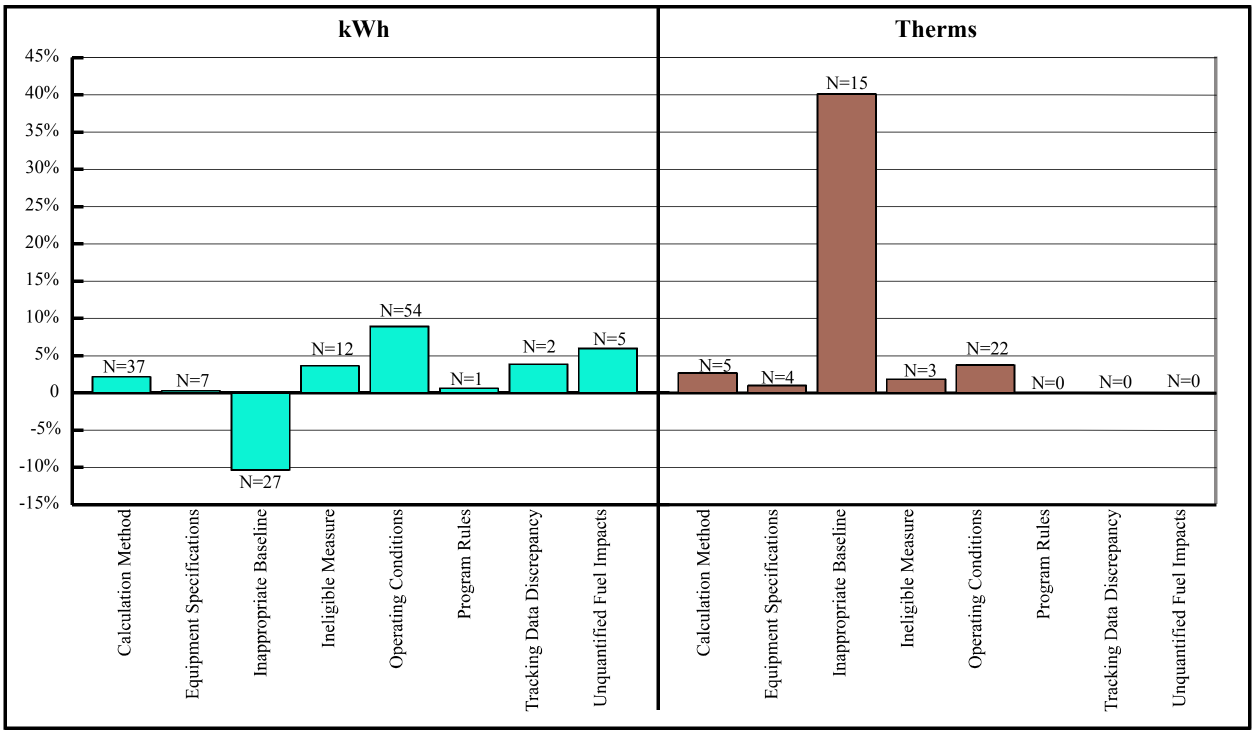

Figure 1. Reduction for discrepancy factors, commercial projects. *Source*: Itron, et al. 2014.

Figure 2 shows the discrepancy factors for the HVAC Controls group as they affect the total claims for all commercial projects. Of note, two projects with operating conditions and unquantified fuel impacts have an outsized effect on the entire custom claim. For all HVAC projects, unquantified fuel impacts are a significant issue, and arise from unclaimed or misapplied heating or cooling savings. For one project, it was even found that the project saved electricity and filed electric savings claim; however, the electricity was generated by a natural gas fired on site cogeneration unit. The ex-post claim was adjusted to show the realized gas savings on the IOU's distribution network.

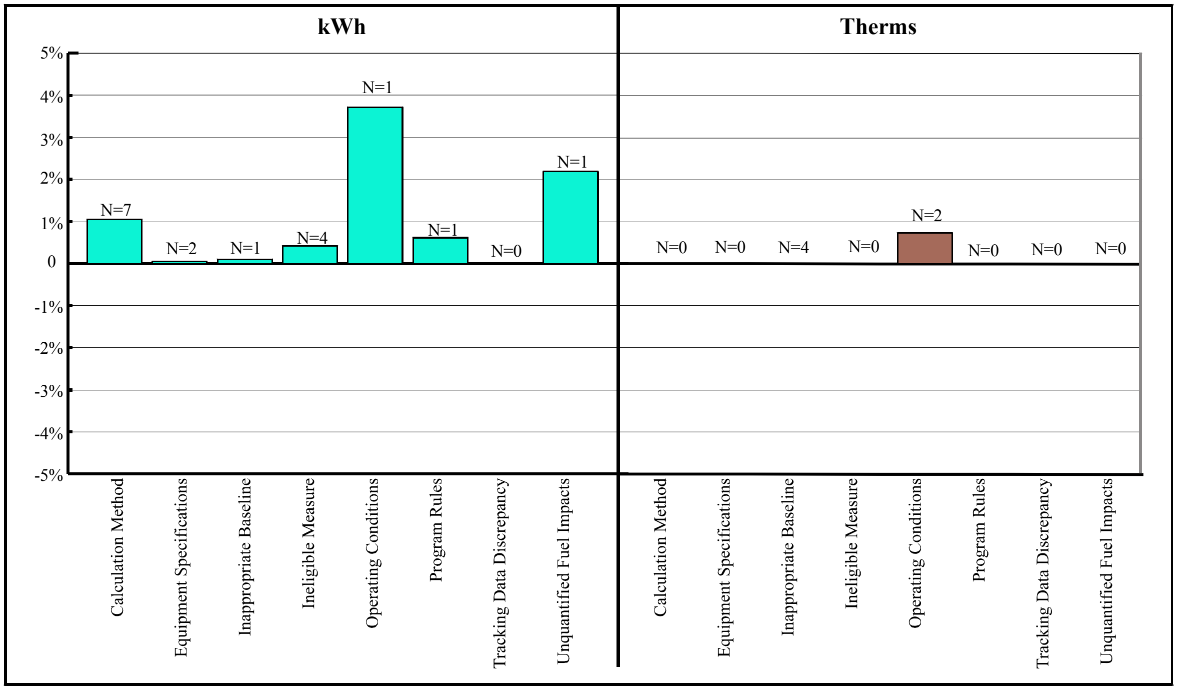

Figure 2. Reduction for discrepancy factors, HVAC Controls Measure Group. *Source*: Itron, et al. 2014.

Figure 3 shows the discrepancy factors for the Whole Building measure group as they affect the total claims for all commercial projects. Operating issues had a large effect, but include 14 projects; equipment specifications and calculation methods show outsized effects on therms despite contributions by only one project in each category. The whole building category, like HVAC Controls, can involve modeling with building simulation software. For some new construction projects, default Title 24 schedules were used in building modeling and compliance software, as opposed to using actual site operating conditions. In some cases, equipment entered in the model did not match equipment found during the evaluation site visit.

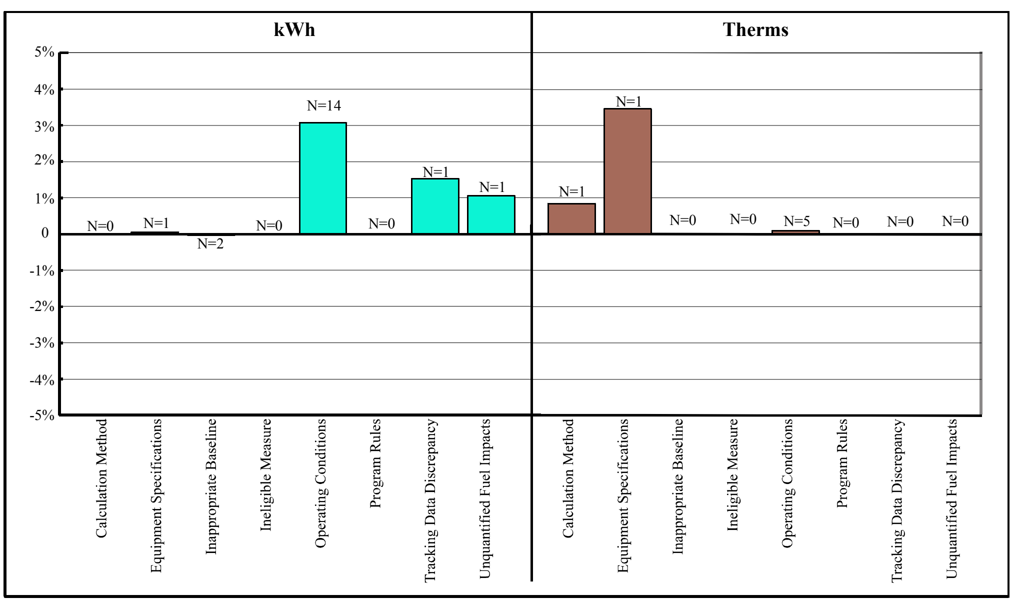

Figure 3. Reduction for discrepancy factors, Whole Building Measure Group. *Source*: Itron, et al.

In addition, ex-ante savings for new construction projects were frequently based on future expected increased occupancy or usage. These observations highlight the finding that the ex-ante savings estimates and calculation methods may benefit from more thorough review by IOU technical staff prior to finalization of incentives and savings claims.

Figure 4 shows the discrepancy factors for the Commissioning measure group. Operating conditions and calculation methods are the primary causes for lower realization rates and do have an impact on the entire commercial claim. This is a particularly challenging group for which to estimate or verify savings. However, for Commissioning projects, ensuring that the measures are fully implemented and stable, and supporting this with longer periods of post-installation M&V, will afford more accurate estimates in the final ex-ante savings claims. Of note, a period of three months was allowed and used for capturing post-retrofit operation several commissioning projects; longer periods, perhaps spanning a full year, may be needed in many cases.

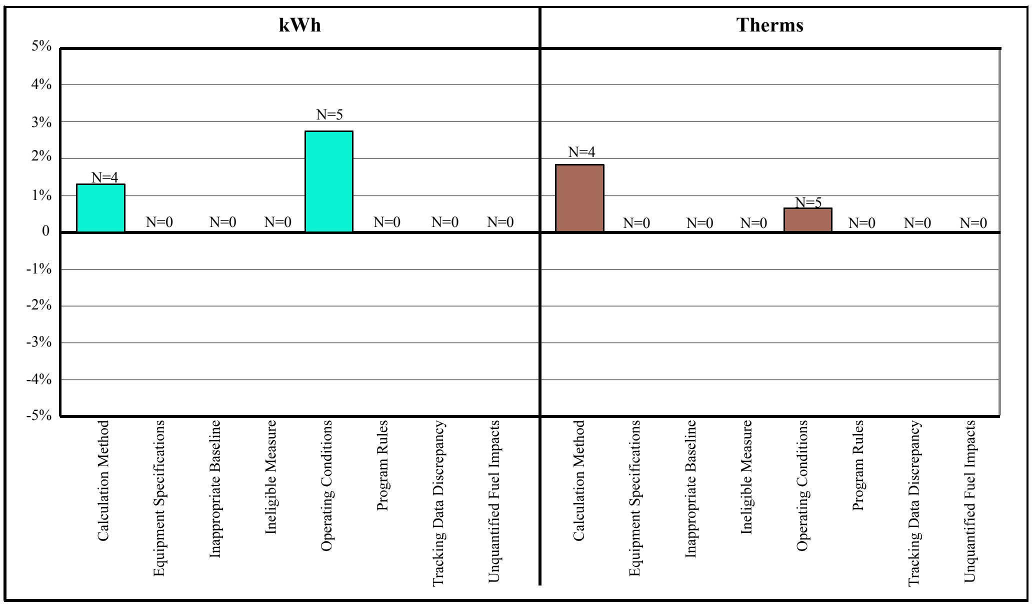

Figure 4. Reduction for discrepancy factors, Commissioning Measure Group. *Source*: Itron, et al. 2014.

Figure 5 shows the discrepancy factors for the HVAC Other measure group. The largest discrepancy resulted in higher evaluated energy savings; inappropriate baselines for eight projects caused a 17 percent change for kWh in the overall commercial claim (although this result is driven by one large project). To address this large discrepancy factor, augmenting previous comments on baseline issues, careful consideration at every stage of the project life cycle is needed, especially with regard to code requirements, the minimum technical requirements when code does not apply, standard practices, and the age / condition of equipment (which governs the possible use of in-situ equipment as baseline).

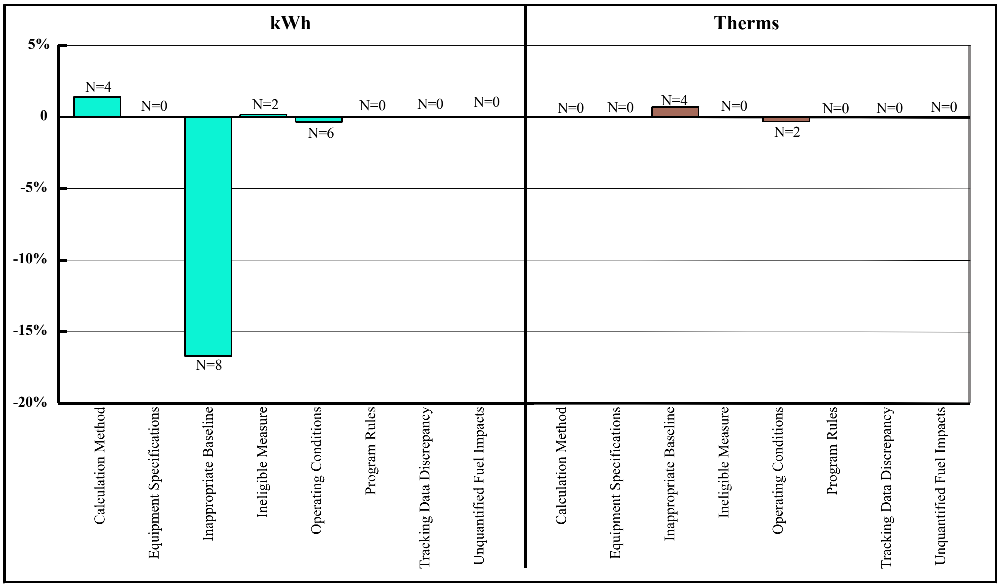

Figure 5. Reduction for discrepancy factors, HVAC Other Measure Group. *Source*: Itron, et al. 2014.

Figure 6 shows the discrepancy factors for the Boiler group as they affect the total claims for all commercial projects. Of note, the discrepancy factors of ineligibility and inappropriate baseline cancel the increase in savings from the change in equipment specifications.

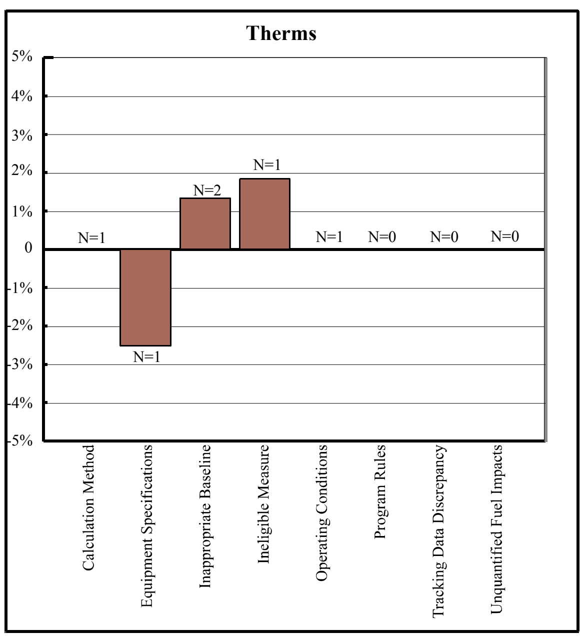

Figure 6. Reduction for discrepancy factors, Boiler Group. *Source*: Itron, et al. 2014

The discrepancy factors for Chillers are displayed in Figure 7. Operating conditions increased the evaluated savings for this group, while a larger number of projects had ineligibility issues due to code compliance and inappropriate baselines. These last two items could also be guarded against by a more thorough application review and adjustments to claims before they are finalized.

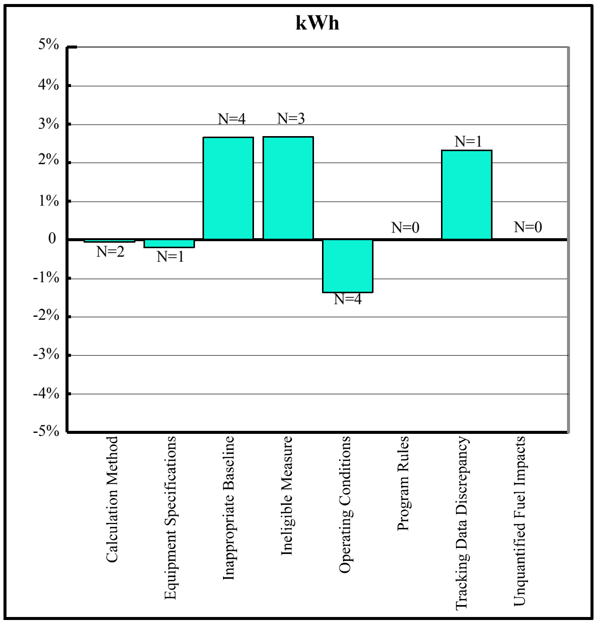

Figure 7. Reduction for discrepancy factors, Chiller Group. *Source*: Itron, et al. 2.

Figure 8 clearly shows the importance of operating conditions for the VSD measure group. Inappropriate baselines also play a common role, but with relatively low impacts. Thus, the most important action item for HVAC VSD projects is to define and document stable annual operating conditions for the pre- and post-installation periods.

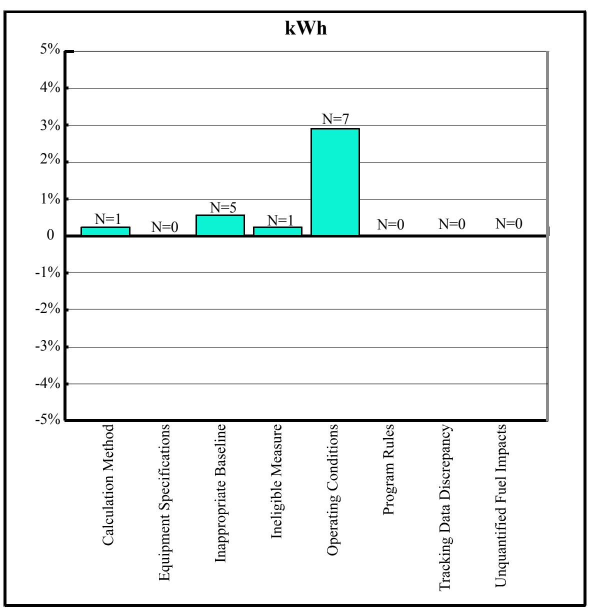

Figure 8. Reduction for discrepancy factors, VSD Group. *Source*: Itron, et al. 2014.

The above figures demonstrate that a few projects can impact the custom portfolio claims quite significantly. While there are common issues, some groups have a factor which rises above all others. Other groups have many factors, while several groups and factors that increased and factors that decreased savings.

Relevance, Importance and Application of the Findings: Suggestions for Reducing the Gap between Claimed and Evaluated Energy Savings

It is important to count on energy efficiency programs to deliver on the claimed savings. The claimed savings are used as an input into utility funding for programs, cost effectiveness of program and resource planning. To better continue and grow energy efficiency efforts, results need to be accurate and defensible. This paper highlights the most important factors driving the difference between claimed and evaluated savings for custom projects in the commercial sector. Utilities and implementers should consider how to best influence project savings claims by determining the interventions and modifications for programs and projects that can best address the issues associated with these factors.

It is tempting to look at only the largest discrepancy factors that affect program and portfolio gross realization rates. However, there may be many separate issues associated with each factor (such as the distinction between baseline and baseline operating conditions) that can be further developed to best define the most helpful modifications. There may also be areas in which the exact intervention is hard to define and difficult to implement. For example, the operating conditions factor is a large contributor to the discrepancy, but what should be done to address this factor? Normal changes to facility operation due to business conditions cannot be captured in all cases and can change through the years, but are greatly facilitated by clear, complete pre and post-retrofit inspections with operating conditions documented and M&V (where appropriate) in order to determine the extent to which the discrepancy could be prevented.

Smaller changes with fairly straightforward potential solutions should be implemented, as these can have a strong chance to quickly bring the realization rates closer to unity. Easy influence on a small area can yield greater results than harder interventions in larger areas. An example is eligibility, with a 2% decrease on the overall commercial electric savings claim and a 45 increase in the gas savings claim. This factor may be easily addressed through screening projects at early stages and through their development, along more thorough review of project documentation. This may be enhanced by real time review as with the ex-ante review process now mandated in California (ALJ 2011) and communication during project development with evaluators on generic situations. Eligibility should be based upon program manuals review and actual grid impacts.

Another important area to address is baseline. As discussed previously, baseline determinations require information and evolving knowledge about codes, standards, industry standard practice, environmental requirements and the operability /remaining useful life of existing equipment, and may benefit by more thorough review and collaborative efforts to make certain claims are appropriate.

Measure groups were analyzed separately from all projects, in order to understand better if certain measures had greater potential for overall improvement than other areas, and what discrepancy factors were most impactful for those measures. This knowledge helps when developing savings claims and evaluating those types of projects and programs that focus on those measures. Program designs, funding, and outreach can be optimized to better address the most common and most impactful discrepancy factors. For example, more detailed project review and checklists for eligibility could be used for measures with known eligibility issues, particularly if the ineligibility factor caused a significant effect on overall portfolio savings.

Gross realization rates less than unity have been an ongoing occurrence for many energy efficiency programs (Kaufman and Palmer, 2010). The goal of increasing gross realization rates will likely require considerable efforts and substantial changes to the current practices in place. Targeting efforts at reducing the gap between claimed and evaluated energy savings is needed to begin to effect these changes and to evaluate the results of the changes. By focusing on the most important discrepancy factors, changes can be made more cost effectively and with greater speed, reducing the frustrations that occur with recurring low gross realization rates.

General recommendations to improve energy efficiency program performance have been provided in several evaluation efforts over the past decades (Itron, et al. 2010). The findings in this paper can help fine tune and hone those recommendations. Armed with how important to the overall savings claims certain factors are, we re-emphasize common and recurring themes:

- Is the baseline clear, considering codes, standard practices, and the remaining useful life of existing systems?
- Are baseline operating conditions correctly identified and used?
- Can operating changes be captured before savings are finalized? Should savings claims be delayed until system operation is stable?
- Are other calculation methods more appropriate? Are inputs appropriate?
- Are all interactions accounted for and are the project boundaries wide enough to capture multiple fuel effects?
- Did the project clear all eligibility screens?

Potential Areas for Future Research

Previous papers have investigated the occurrence of discrepancy factors overall and by measure types for commercial projects (Lutz and Tirumalashetty 2012). This paper investigates both the occurrence and the energy impact of similar discrepancy factors for common commercial measure groups.

While the findings are broadly applicable, there are limitations to the research conducted to date. Limitations include the small number of projects studied per measure group. To address this limitation, continued collection of data for the discrepancy factors for custom commercial projects should be considered in the normal course of site-specific evaluation efforts, and expanded as applicable to industrial and agricultural projects. To increase the number of projects studied, standardized measure groups and discrepancy factors should be developed and used, to enable the comparison and compilation of projects. As samples expand, a greater number of, and more specific measure groups, along with an expanded number of discrepancy factors and project-specific reasons for various discrepancies, can be used to help implementers hone in to specific reasons for discrepancies for specific types of projects. A broader vision entails a common database for projects involving different states and jurisdictions, different IOUs, and an array of contributing firms, while acknowledging the complications, training and planning needed to combine results from disparate regions, types of programs, and contributors.

An intensive analysis into operating conditions should also be considered, perhaps incorporating more discrete discrepancy factors. How often is a change in operating hours, power draw, system operation, or other factors responsible for the discrepancy? Which factors can be adjusted for prior to final IOU savings claims, and which occur as a part of normal building use or occupancy changes that the IOUs cannot control or adjust for before final savings claims are made?

The author's note that the analysis conducted for this paper involved commercial custom energy efficiency projects at the four major California investor owned utilities. Many of the projects studied have long histories with well-established program rules and highly knowledgeable staff and implementers. However, these same programs may have some ingrained practices that may affect the savings gap. Different states and utilities need to determine the extent to which these findings are valid for their particular efficiency programs.

While understanding the magnitude of the discrepancy factors is important, the essential next steps need to be taken, translating knowledge into meaningful actions that can reduce the gap between claimed and evaluated savings. Recommendations contained in this paper are a starting point, but can be further expanded as we put the ideas into action and gain more insights into the steps needed to align energy savings estimates throughout the evaluation process. The expectation that the evaluated savings will better match the claimed savings, at least for factors the IOUs can control, will narrow the savings gap and improve the effectiveness – and reliability - of custom programs in any jurisdiction where they are in use.

References

ALJ Decision 11-07-030 July 14, 2011. 2011. Third Decision Addressing Petition for Modification of Decision 09-09-047. http://docs.cpuc.ca.gov/published/FINAL_DECISION/139858.htm

Itron, Inc., Energy and Resource Solutions, Energy Metrics, Mad Dash, Inc., Michaels Engineering, PWP, Inc., Katin Engineering. 2010. 2006-2008 Evaluation Report for PG&E Fabrication, Process and Manufacturing Contract Group. CPU0018.01. www.calmac.org. Oakland, CA.: Itron, Inc

Itron, Inc., DNV / KEMA GL, Energy and Resource Solutions, Energy Metrics, Michaels Engineering, PWP, Inc., Katin Engineering Consulting, Robert Thomas Brown Company, Leidos LLC, Warren Energy Engineering LLC. 2014. *2010-2012 WO033 Custom Impact Evaluation Report.* www.calmac.org. Oakland, CA.: Itron, Inc.

Kaufman, N. & Palmer, K. 2010. """Energy Efficiency Program Evaluation: Opportunities for Learning and Inputs to Incentive Mechanisms". Report RFF DP10-16. Washington, D.C.: Resources for the Future.

Lutz, A., and Tirumalashetty, V. 2012. "Measure by Measure – the real reasons for Gaps in Claimed and Evaluated Savings" *In Proceedings of the ACEEE Summer Study for Energy Efficiency in Buildings.* Pacific Grove, CA. American Council for an Energy-Efficient Economy.