Utility Codes and Standards Programs: How Much Energy Do They Save?

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ABSTRACT

Adoption and implementation of energy-efficiency standards can be a very cost-effective way to increase the efficiency of new buildings and appliances. Government regulatory agencies are responsible for such codes and standards (C&S). For about two decades, the Energy Commission played the major role in California's efforts to upgrade such standards. In the latter half of the 1990's, California utilities began to actively participate researching, proposing, and promoting C&S as a way to reduce utility loads. Unlike resource acquisition programs, however, energy savings from utility C&S programs depend on a long chain of efforts, are complex to estimate, and may take years to occur. Nevertheless, their large impacts and cost-effectiveness justify utility efforts and incentives for utilities to engage in such efforts. The California Public Utilities Commission adopted a sophisticated protocol for quantifying utility C&S program impacts. It accounts for gross first-year energy savings from each code/standard, effects of market changes, what market penetration would have occurred if the standard had not been implemented, non-compliance, and what portion of savings can be attributed to the utility activities. This paper discusses the protocol and how it is being applied to evaluate impacts of California's current standards, findings from the evaluation to date, and potential changes to the protocol as a result of the current study. The authors believe both the approach of involving utilities in C&S development and the method discussed for evaluating their impacts will be essential elements required to scale up today's efficiency efforts to provide tomorrow's solutions.

Introduction

Efficiency standards set minimum efficiency levels that new appliances and buildings must meet or exceed. Because, at least in theory, they eliminate low-efficiency products from the market, standards have become an important mechanism for reducing energy consumption. In the 1970s, states began establishing regulatory frameworks for developing, adopting, and implementing such standards. In addition, the Federal government began adopting national appliance/equipment standards and issuing mandatory, voluntary, and model building efficiency standards. Both the Federal government and states have continued developing and upgrading their efficiency standards.

In many ways, California has served as a model for other states in this process. Recent active involvement by California utilities in the process is likely to become a model for other regions as well. This paper addresses the important question of how the State of California is treating the utilities' activities and investments to enhance both appliance and building efficiency standards and lessons learned from that experience.

California's Energy-Efficiency Standards

Standards Development Process

To address concerns about projected growth of electricity demand in California, the Legislature passed Assembly Bill 1575 (the Warren-Alquist Act) in 1974, which created the California Energy Resources Conservation and Development Commission (referred to as the California Energy Commission, or CEC) (Pennington 2004a, Pennington 2004b). One major responsibility was to adopt both appliance and building energy-efficiency standards. The CEC was given authority to establish these standards based on criteria in the Warren-Alquist Act and subsequent legislation.

The CEC created staff positions and processes to develop and adopt these standards Into the 1990s, CEC staff and consultants conducted most of the research needed to establish the standards. Building standards are in Title 24 of the California Administrative Code and appliance standards are in Title 20. In some cases, the CEC drew upon research and proposed and voluntary standards from other organizations such as the American National Standards Institute and American Society of Heating, Refrigerating, and Air Conditioning Engineers.

Utility Role

In the late 1990s, California's investor owned utilities (IOUs) started to take an active role in the standards development process, motivated by the ability of standards to make permanent, market-wide efficiency improvements and their attractive cost-effectiveness relative to acquisition programs. Utilities began actively engaging in the process in 1998 when they began preparing codes and standards enhancement (CASE) initiatives (Mahone et al. 2005).

For the 2005 Title 24 and 2006 Title 20 standards, California's IOUs conducted a jointly coordinated Statewide Codes and Standards Program (C&S Program) funded through the Public Goods Charge (Pennington 2004a). The C&S Program contributed expertise, research, analysis, and other support to the CEC process (Mahone 2005). For 2005 Title 24 updates, 12 standards changes supported by detailed C&S Program activities were adopted by the CEC. For 2006 Title 20 updates, the C&S Program supported the upgrade or adoption of 27 appliance standards. Since 2004, the CEC and the C&S Program have continued their efforts, focusing on Title 20 and 24 standards upgrades expected to go into effect in the 2008-09 timeframe.

The California Public Utilities Commission (CPUC) regulates the IOUs and establishes energy-efficiency savings goals for them. For 2006 and beyond, the CPUC established ambitious energy-efficiency targets and in a 2004 decision laid the groundwork for starting to count the energy savings resulting from the C&S Program. The CPUC stated: "In order to meet today's adopted goals, program administrator(s) should aggressively pursue programs that support new building and appliance standards… Only actual installations should be counted towards the savings goals."[1] The challenge this presented was how to determine the energy savings attributable to the C&S Program in a consistent, defensible manner.

[1] Decision 04-09-060, *Interim Opinion: Energy Savings Goals for Program Year 2006 and Beyond*, September 23, 2004, Finding of Fact #27 and #14.

Development of Savings Assessment Methodology

The nature of the C&S Program and its effects require applying a different impact evaluation methodology than the approach used to evaluate typical utility energy-efficiency programs. Some of the reasons a different approach is required include:

- Standards are adopted and implemented by a state agency, not the utilities.
- Utility efforts influence standards adoption rather than customer behavior.
- Utilities are not the only parties that affect adoption of new standards.
- Customers do not opt to be "participants" in the standards—the standards apply to all covered products and buildings. Consequently, there are no non-participants.
- Standards compliance is determined and enforced by local or state government agencies; utilities do not enforce building/appliance standards to ensure compliance.
- Standards affect all covered buildings/appliances entering the market.
- Natural energy-efficiency market trends affect the savings attributable to standards.
- Utility acquisition programs interact with standards.

Initial Approaches

The first effort to assess energy savings due to utility efforts occurred in 2001 and applied to code changes that year (HMG 2001). The project report provides limited information on the methodology, indicating that it "…maintained consistency with the CEC assumptions and estimating methods as much as possible" (HMG 2001, p.6). Best described is the method used to determine what portion of estimated statewide savings should be attributed to utilities. The procedure assigned a level of utility involvement to 10 different steps in the code development process. The details of this process, however, were not fully delineated in the report.

In 2004, a second study (ADM 2004) examined the prior attribution method. This study found that ratings on only three of the 10 steps were statistically significant in determining attribution, and one of the three had a counterintuitive coefficient.[2] ADM decided to apply a different attribution method—all energy savings were attributed to utilities for standards for which utilities prepared a CASE report and none were assigned for the remaining standards. ADM also discussed a "decision theory" approach for analyzing attribution, though it was not applied in the study. Though not implemented, this approach offered some innovative concepts.

The third attribution approach that has been used is documented in Mahone (2005). This method defined five factors as leading to the adoption of a standard. These included:

- How important it was for a substantial share of energy efficient products/measures of this type to be in the market
- How important it was that new test methods or research results be developed and how much effort was required to do so
- How new or innovative the idea of developing a standard for the appliance or measure was
- How important the analysis presented in CASE reports was to adoption
- How important and extensive the effort required to work with outside stakeholders was

[2] From our review, it appeared likely that multicollinearity was present and it had affected the estimated coefficients.

These factors were assessed in terms of their importance to adoption of each standard—weights were assigned, totaling 100% across the factors. Then the C&S Program's effect on each factor was estimated by assigning a score that could range from 0% to 100% for each factor. The final C&S Program attribution score was the sum of the products of the weights and Program scores for each factor. A group of CEC, utility, and consultant staff developed the weights and scores.

The study also defined a detailed methodology to estimate the energy (kWh and therms) and demand (kW) savings to credit to utilities for their C&S Program activities. Components in this methodology included initial unit and market energy (and demand) savings; a deduction to account for market efficiency trends; an adjustment for incomplete compliance; an adjustment accounting for when standards would have been adopted without the C&S Program; the attribution adjustment; and a process allocating savings to the individual IOUs.

The fourth C&S Program study (Khawaja et al. 2007) focused on two key analysis components in the prior study—trends in market efficiency and compliance with the standards.

The Components of a Comprehensive Impact Analysis

In 2006, the CPUC published a detailed program evaluation protocol (TTWT 2006) covering a wide range of program types, including utility codes and standards programs. The C&S Program protocol largely reflects the methodologies used in the last two studies mentioned above. This protocol succinctly defines what its application is intended to produce:

> "The end result … is the identification of the net ex-post energy savings achieved from code and standard changes above and beyond what would naturally occur in the market through normal non-code/standard driven technology adoption behavior and through the normal cycle of codes and standards updating activities. The resulting net program induced energy savings are the savings that are caused by the program's efforts."(TTWT 2006, p. 84)

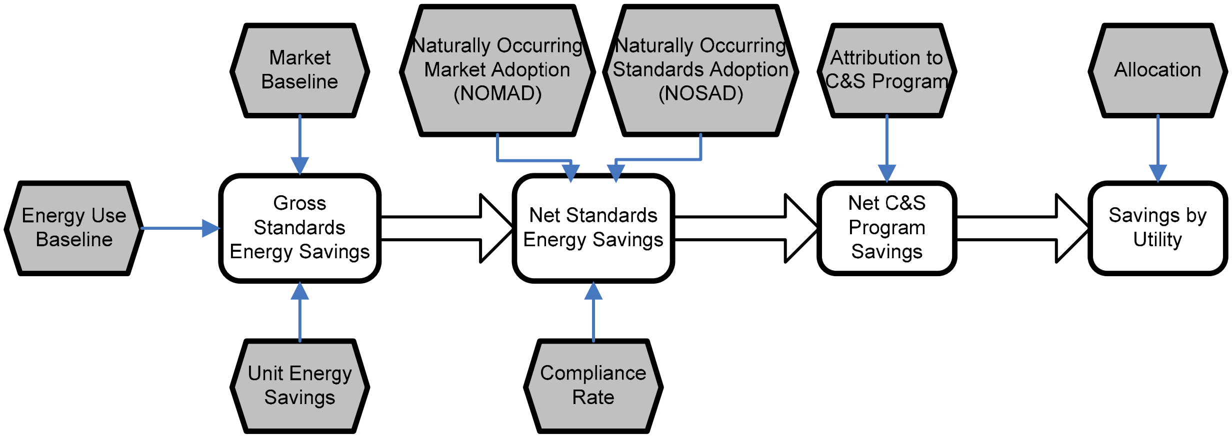
We use Naturally Occurring Market Adoption (NOMAD) to refer to non-standard driven technology adoption. We refer to effects of the "normal" cycle of standards updates as Normally Occurring Standards Adoption (NOSAD). The calculation of savings attribution for the C&S Program can be written in two representational equations:

Net standards induced effects = [Gross standards savings – (NOMAD + Non-compliance)] – NOSAD
*Net energy savings attributable to C&S Program = Net standards induced effects * program attribution %*

The effect of NOMAD is to reduce, over time, net savings attributable to standards by market growth in efficiency that would have occurred without the standards. Net savings also depend on the extent of compliance with standards so an adjustment is made for non-compliance. NOSAD is used to terminate counting C&S Program savings for items that would have been covered by equivalent standards adopted without the Program. Program attribution has been described already. Each of these components is discussed below.

The components accounted for in the impact analysis are illustrated in Figure 1. The major steps in the analyses are discussed in the following paragraphs.

Figure 1. Components of C&S Program Impact Evaluation



Gross standards savings. The estimate of impacts begins with a standard's estimated gross savings. This value depends on the difference between baseline energy consumption and consumption of the efficient product or building measure.

The other parameter determining gross savings is the number of units affected by the standard. For appliances, this is the number of new appliances sold that the standard covers. For buildings, this number depends on the quantity of new buildings and major renovations covered by a standard and the proportion that would use the covered measure. To forecast future impacts of standards, it is necessary to project appliance sales and construction rates. To verify the impact requires knowing the actual sales and construction rates.

NOMAD. Naturally occurring market adoption can be depicted by a curve capturing expected trends in energy efficiency if a standard had not been adopted. If efficiency would have trended upward, then the net savings attributable to the standard would decline over time.

The last two reports described above (Mahone 2005 and Khawaja et al. 2007) addressed this effect by projecting trends in adoption of high-efficiency appliances and measures. The first report estimated a basic linear trend—penetration of items meeting the new standard was forecast to increase linearly up to 100% of the market in a given number of years (Mahone 2005). The group that estimated attribution was asked to provide these estimates also.

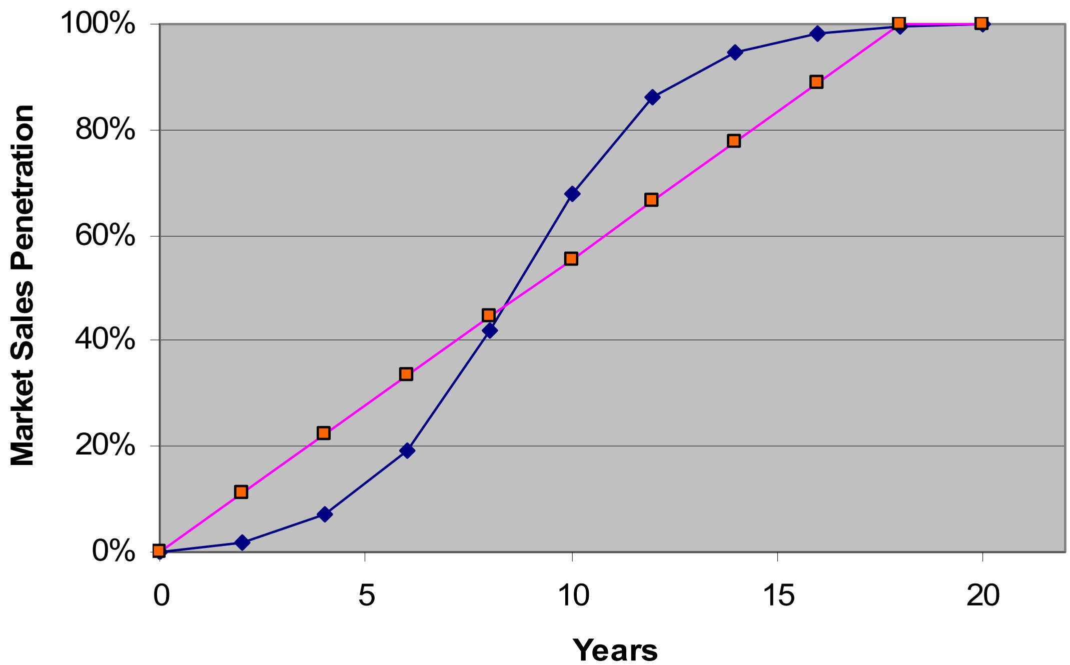
The second report used an approach that differed in two key ways (Khawaja et al. 2007). First, market penetration estimates were provided by groups of experts that varied by appliance and building measure. The groups included industry representatives as well as the groups used in the prior study; the objective was to add direct industry knowledge and reduce the potential for bias. Second, the market penetration trend was estimated using an approach based on the Bass curve used frequently to characterize market diffusion.[3] This formulation permits taking into account effects of consumers who tend to be "innovative" and lead the market in adoption of higher efficiency items and those who tend to be "imitative" or follow the lead of other consumers. Using this method, market penetration can be represented as an S-shaped curve, which appears to fit empirical diffusion and market adoption data better than a linear curve. Experts' curves were obtained using a Web-based tool that allowed them to adjust sliders that

[3] For a good reference describing and comparing various methodologies for predicting market penetration rates, including the standard Bass curve, see S.T. Gilshannon and D.R. Brown."Review of Methods for Forecasting the Market Penetration of New Technologies." *Pacific Northwest Laboratory* PNNL-11428 (December 1996).

changed the shape of the trend curve until they were satisfied that the curve represented their expectations of market trends. Experts also were able to specify the maximum market penetration that the high-efficiency appliance or measure would reach within the forecast period.

Figure 2 compares the original linear market adoption curve and a typical S-shaped curve generated using the second method. In both cases, the penetration is estimated to reach 100% of sales in about 18 years. The curves illustrate how these different approaches can significantly affect the penetration estimates at different points in time, especially in the early years.

Figure 2. Comparison between Original Linear and Bass NOMAD Curves



Compliance. After trying to estimate the *ex ante* compliance rate separately for each standard, authors of the first study (Mahone 2005) chose to set compliance at 70% for each standard. The group decided information was insufficient to establish individual compliance rates and decided 70% was a reasonable average rate.

The second study (Khawaja et al. 1007) established *ex post* compliance rates for a subset of standard based on empirical data. Field studies were conducted to estimate compliance with building and appliance standards. Estimated compliance for building standards varied from 0% to 72% and compliance with appliance standards ranged from 37% to 100%. Low compliance rates were partially due to the fact that the study was done less than a year after the standards went into effect.

NOSAD. Normally occurring standards adoption was estimated in the first study by the same group who estimated the other components. Mahone (2005) acknowledged the difficulty and uncertainty in estimating NOSAD, noting "…judgments, of course, are difficult to verify with any precision, because it is difficult to predict future CEC staff resources or California's political will to adopt more stringent standards. For this reason, the committee tried to be conservative in its estimates, opting for shorter adoption periods whenever there was a lack of consensus" (Mahone 2005, p. 18). As stated earlier, the effect is to attribute no more savings to new items once the NOSAD period is reached. This component was not analyzed in Khawaja et al. (2007).

Attribution. The attribution method used in Mahone (2005) was described above. For appliance standards, the estimated attribution ranged from 45% to 95% depending on the appliance. For buildings standards it ranged from 32% to 85%. Attribution was not addressed in Khawaja et al. (2007).

Results from Past Studies

The methodology to estimate C&S Program savings has been embedded in a spreadsheet developed by Heschong Mahone Group ("HMG spreadsheet"). Mahone (2005) describes the elements and calculation in the spreadsheet. The latest version of the HMG spreadsheet incorporates findings on NOMAD and compliance rates presented in Khawaja et al. (2007).

Using the HMG spreadsheet assumptions, results from Khawaja et al. (2007), and additional CPUC information, we calculated initial estimates of impacts of the standards and the savings credit attributable to the C&S Program (see Table 1). For 2006-08, initial estimates of savings attributed to the Program were between 10% and 12% of the total IOU goals. CPUC policy decisions detailed below required that net savings counting toward the savings goals be discounted by 50%. Even after the adjustment, estimated savings were a significant 5% to 6% of the goals. Based on C&S Program expenditure information from the utilities, these credited savings were achieved at a Program cost of about $0.01/first-year kWh.

Table 1. Initial Savings Estimates for 2005 Title 24 and 2006 Title 20 Standards

Savings Category	CPUC Savings Goals (2006-08)	Net Annual Standards Induced Effects	Savings Attributed to C&S Program	50% Savings Credited to IOUs	Credited Savings as % of CPUC Goals
Energy (GWh)	6,811	1,631	636	318	5%
Demand (MW)	1,448	481	173	86	6%
Gas (MMTh)	112	18	13	7.0	6%
Note: All energy savings associated with standards are the sum of only the first-year savings for appliances/measures installed during that year. Demand savings are summed over the three years. All savings from the standards are *ex ante* estimates.					

Current Efforts to Estimate C&S Program Savings

Through a series of decisions, the CPUC has stated California utilities can claim credit for their advocacy efforts to upgrade appliance and building standards. For the 2006-08 cycle, the CPUC said, "In evaluating whether the 2006-2008 portfolios actually meet or exceed our adopted goals for that program cycle on an *ex post basis*, the utilities should credit 50% of the *verified* savings associated with pre-2006 codes and standards advocacy work towards the goals" (CPUC 2005). Verified savings are those determined by evaluation studies to independently refine the estimates in each element of the HMG spreadsheet.

A unique feature of the CPUC determination merits note. The 50% credit was a recommendation from CEC and CPUC staff to strike "…an appropriate balance between too much and too little acknowledgment for these past program efforts" (CPUC 2005, p. 6). This is a policy decision and is not built into the adopted evaluation protocol.

As the preceding section suggests, utility efforts to upgrade energy-efficiency standards have the potential to generate significant energy savings cost-effectively. Given this potential, the CPUC has taken the following positions:

- For planning purposes: "[Savings from the C&S Program prior to 2006] will be considered as 'bonus' savings, e.g., a hedge against inherent risks that other programs may not meet their performance goals, as we consider the final program plans during the compliance phase of this proceeding. For this purpose … utilities should assess whether the 2006-2008 portfolio plans are expected to meet the savings goals using a 'with and without' scenario with respect to savings from pre-2006 codes and standards. The 'with' scenario should credit 50% of the *ex ante* GWh, MW and Mth estimates presented in the HMG Report towards the goals" (CPUC 2005, p. 130).
- "On a forward looking basis, savings from codes and standards advocacy work undertaken in 2006 and beyond *will be counted* when calculating either net resource benefits ('performance basis') or cost-effectiveness (TRC or PAC tests). The final protocols for estimating these savings and verifying them will be established during the EM&V phase" (CPUC 2005, p 130).
- "As stated in that decision [D.05-09-043], for this purpose the C&S savings are to be *verified* (as opposed to *ex ante* estimates used for planning purposes). Energy Division's EM&V contractors are in the process of verifying those savings estimates, and Energy Division will be including the verified numbers in its Annual Verification Reports" (CPUC 2007, p. 140).

In keeping with these decisions, it is essential to enhance the methodology for accurately attributing energy savings to the C&S Program prior to 2006 and into the future.

Planned Evaluation Approach

An evaluation plan to produce verified savings estimates for pre-2006 C&S Program efforts was prepared (RLW et al. 2008). The plan also lays the groundwork for the approach to evaluate current and future C&S Program efforts. Highlights of the approach are discussed below; note that some details may be fine tuned as the study progresses.

Gross standards savings. This research will permit "truing up" some of the values used in the original analysis to estimate gross savings from each of the standards. For example, actual product sales and building construction statistics will be used when available. In addition, the original unit energy savings will be examined to ensure they are calculated consistently with other analysis components such as how the naturally occurring market adoption is estimated.

NOMAD. Several steps will be taken to enhance the NOMAD analysis. The group of measures to which revisions in Khawaja et al. (2007) were applied will be expanded. Also, the expert group providing inputs will be enlarged. A more complete Delphi approach permitting the experts to share knowledge and revise their initial NOMAD estimates will be employed. The general approach of estimating a Bass-type curve will be implemented, but the possibility of applying it to estimate trends in average efficiency levels instead of penetration of standard-compliant items only will be examined.

Compliance. The compliance analysis will be similar to that reported in Khawaja et al. (2007). The main differences will be that the Title 24 sample sizes will be increased. Also, compliance with the 2001 Title 24 will be assessed for specific measures to gain insights into compliance trends. The Title 20 sample sizes also will be increased and more appliances will be included.

Given that nearly two years have passed since the last study, it is likely that compliance rates have increased. Because of the nature of a snapshot in time, it is also possible hat eventual compliance might increase between our measurement and the end of the Program cycle.

NOSAD. This component of the C&S Program impact evaluation is not very important in assessing near-term effects of pre-2006 efforts because it is unlikely that equivalent standards would have been adopted without the Program in the near term. However, when utilities begin receiving credit for longer-term energy savings from standards it will be important to accurately estimate when normally occurring standards adoption would have occurred.

The current study will obtain expert opinion on the likelihood each standard would have been adopted in the 2006-08 timeframe. More importantly, it will develop the analytical framework for estimating NOSAD effects in future studies.

Attribution. The attribution method used in the current study is based on the one described in Mahone (2005). One modification to the prior method is development and application of a set of criteria (such as transparency, consistency, and completeness) to select factors affecting adoption of standards. A second difference in our approach is using expert groups containing industry members to assess how important these factors were to adoption of each standard. A third difference is that the evaluation team will estimate the weights assigned to the utility efforts to adopt each standard. We believe this approach will be less open to bias in the estimates.

Since this activity will require retrospective assessments of the Program's effects, the approach includes a review and summarization of the record documenting the history of each standard. The determination of Program weights will be based on this historical record.

Analytic challenges. Some evaluation plan details may be modified over time as more information becomes available. Many of the possible changes reflect specific challenges in conducting this type of study.

Several challenges result from the divergence between a Title 24 *measure* and *whole-building* perspective. The C&S Program targets individual measures and when standards are adopted for individual measures they also affect Title 24 requirements established for whole-building performance. Buildings can comply on a prescriptive or performance basis; in a performance approach, some measures can be traded off for others as long as the whole building meets the minimum performance requirement. The HMG spreadsheet and methodology, however, were designed around the prescriptive measure basis. To assess Title 24 compliance, our methodology includes both an analysis at the building and at the measure level, taking into account which approach the builder used to demonstrate compliance.

This dichotomy also affects the NOMAD analysis since past analyses have focused on naturally occurring adoption of individual measures, not efficient buildings. Our method addresses this issue estimating for whole-building, as well measure, efficiency trends.

Another challenge will be obtaining valid inputs on Program attribution for activities that occurred several years ago. As noted earlier, our evaluation plan includes developing objective documentation on the Program's role in the evolution of each of the standards and using this to establish a common basis upon which we can develop attribution estimates.

In all cases, the lessons learned in the course of conducting this retrospective analysis will provide valuable input to develop the evaluation methodology used in the future. The long-term objective is to minimize sources of uncertainty in future evaluations that are unavoidable in the current study of past C&S Program effects.

Conclusions and Implications

This paper focuses on determining energy savings that could be credited to utilities for their efforts to upgrade energy-efficiency standards. However, accurately estimating savings from efficiency standards should be important to all organizations involved in proposing or developing standards; this includes state and Federal agencies and various advocacy groups. The authors believe that many of the insights from the methods developed to evaluate the utilities' C&S Program are relevant to assessments of other investments in standards upgrade processes.

The C&S Program sponsors research, provides technical information, develops test procedures, works with affected industries, and conducts other steps to influence the institutional standard-setting process. Evidence to date from California's Program suggests that utility standards' advocacy efforts have the potential to produce significant energy savings for a relatively modest cost to utilities.

So far, C&S Program costs have been small compared to utility expenditures on all energy-efficiency programs. For example, in the 2004-05 period, less than 0.5% of the utilities' energy-efficiency program expenditures went to the C&S Program. Using current CPUC rules, utilities' credit from these efforts amount to about 5% of their 2006-08 efficiency goals.

Because of this large potential, it is important to encourage utilities to continue targeted efforts to upgrade efficiency standards. On the other hand, remaining uncertainties and difficulties in calculating verified C&S Program savings suggest that diverse utility energy-efficiency programs should continue to play a significant role in the overall efficiency portfolio. The Natural Resources Defense Council (NRDC) posed the dilemma as summarized in a CPUC document, "On the one hand, NRDC is concerned that not counting the savings associated with pre-2006 codes and standards advocacy … would create a disincentive for codes and standards work during the upcoming program cycle. On the other hand, NRDC is concerned that crediting these savings towards the 2006-2008 goals could reduce utility motivation to pursue all cost-effective savings during that funding period" (CPUC 2005, p. 92). The CPUC has taken significant steps toward resolving this dilemma and striking an appropriate balance.

Several states and utilities have expressed an interest in the proper role for utilities in upgrading efficiency standards and how their efforts should be encouraged and incentivized. We believe findings from prior and current research provide a solid foundation for future efforts to appropriately calculate energy savings attributable to new standards and to determine the proper allocation of credit to utilities. The ongoing evaluation described here will add significantly to the analytic capabilities developed in the past. With a reliable, credible method for analyzing energy savings from standards and allocating credit to utilities, utility codes and standards programs should become a viable component of energy-efficiency program portfolios throughout the country.

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