Highly Cost-Effective Savings

Appliance Efficiency Standards and Utility Programs

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ABSTRACT

This paper[1] describes the effectiveness of California residential appliance energy efficiency standards[2], and the role of codes and standards (C&S) programs as a highly cost-effective component of a portfolio of energy efficiency programs. It describes the methods the California statewide C&S program uses in supporting standards development, proposes an evaluation framework for estimating and crediting C&S program energy savings, and discusses the technical issues that must be addressed in preparing such estimates. Finally, this paper presents recommendations to program planners and policymakers on ways to incorporate C&S programs as an integral part of an efficiency program portfolio. Only a few other states have adopted appliance standards, while most have adopted building efficiency standards. The methods and recommendations in this paper will apply to many other states and other efficiency program portfolios.

Codes and Standards Program Background

California has a history of strong standards for the efficiency of appliances (and of buildings), and they are a very important part of the state's strategy to make efficiency a central part of its energy strategy. These standards complement federal appliance efficiency standards, which cover a smaller number of appliances.[3] Appliance standards govern the sale of energy-using equipment, preventing the sale of less efficient products. As such, they play a unique role in the marketplace. The standards have two desirable effects: they bring the late adopters along toward improved efficiency, and they reduce the drag on market transformation efforts to push the efficiency curve forward. Standards are part of the latter stages of the technology adoption cycle, coming after efficient technologies have been developed and proven effective, and standards provide very cost effective energy savings to California.

In the past, the primary responsibility and effort in developing standards changes was taken on by the California Energy Commission (CEC) staff. This started to change in the late 1990's, when the utilities' codes and standards (C&S) programs started to invest substantially in improving the standards,

[1] This paper summarizes a portion of the findings of a white paper prepared by a team of consultants for the Southern California Edison Co., in support of California's statewide codes and standards program. The white paper was addressed to program planners, portfolio managers and the policymakers at the California Public Utilities Commission. See References, HMG 2005, for the full citation of the white paper.

[2] Much of the content of this paper will apply as well to nonresidential appliance standards, and to building efficiency standards.

[3] The federal Energy Policy Act preempts states from adopting more stringent standards for appliances that are covered by federal appliance standards.

using public benefits monies allocated by the California Public Utilities Commission (CPUC). Many of the standards changes were further supported by efforts made through the utilities' on-going market transformation programs; some were only possible because of the familiarity with the technology that utility programs developed. The 2006/2007 appliance standards updates, adopted in 2004, cover a wide range of energy-using equipment, including refrigerators, lighting equipment, air conditioners, boilers, clothes washers, etc. The C&S program supported the upgrade or adoption of 27 of these appliance standards. Since 2004, attention at the CEC and in the utility C&S program has shifted to the next standards cycle. This work is planned to be completed in 2006, with adoption in December, 2006. The standards changes would then take effect on July 1, 2008.

Efficiency standards are recognized as an important component of California's energy policy and its ability to meet aggressive goals to reduce energy consumption and demand. The CPUC, in setting savings goals for the utilities' energy efficiency portfolios for 2006 and beyond, established very ambitious targets for energy efficiency (CPUC 2004). In its decision, the CPUC has laid the groundwork for counting the energy savings that will result from the utilities' C&S programs as part of their portfolio achievements: *"In order to meet today's adopted goals, program administrator(s) should aggressively pursue programs that support new building and appliance standards…"*

Estimating Savings

The process of estimating savings for C&S programs begins with a calculation of the single year energy savings that can be expected from implementation of the new standards. That done, one can then project those savings forward to derive a lifetime savings estimate.

Three estimates of energy savings attributable to recent rounds of efficiency standards in California are available, including both appliance standards and building standards. Each is the result of a study that looked at the different measures that were adopted, and summarized the estimated statewide savings attributable to them. These are all "first year" estimates of savings, or estimates of the savings that would be achieved from one year of new construction and appliance/equipment purchases. The results are somewhat different and differently formatted, as the studies were done at different times by different people, as indicated in the table and references.

There is insufficient space here to compare and contrast the different estimates, but in Figure 1**Error! Reference source not found.** we present a "rolled-up" estimate of the annual savings that can be expected from the three rounds of standards, of the portion of those savings that could be attributed to the utility C&S programs. These numbers are single year estimates; they correspond to the savings that could be expected from each of the standards in 2006. The savings are relative to the efficiency levels of the 2000 baseline year. The sum of these savings, then represents all of the standards savings expected to "come online" in 2006.

There are two sets of savings numbers in Figure 1. The Total Statewide Savings are just that: the savings expected throughout California from all new buildings and appliance purchases subject to the standards requirements. The savings Attributable to Program are the portion of the statewide savings that can be attributed to the efforts of the C&S program in helping to get those standards adopted. The full White Paper (HMG, Mahone, Brown et al, 2005) provides a discussion of the attribution methodologies used among these various estimates.

Also included in this table is the total statewide savings goal for utility programs in 2006 (CPUC 2004), as a savings-per-year value (not accumulated from other years). The savings attributable to C&S program contributions, for the 2005 and 2006 standards alone, could amount to over 15% of the 2006 electricity savings goal. There are a large number of issues, however, that must be considered and agreed-upon in deciding how to handle these savings estimates and their relationship to the statewide savings goals. These are briefly discussed below.

Cycle/Sector	Electric Energy			Electricity Demand			Gas Energy		
	GWh			*MW*		*% Statewide Goal*	*Therms*		*% Statewide Goal*
Total Statewide Savings									
2001/Residential[A]	131			199			800,000		
2001/Nonresidential[A]	63			41			650,000		
2001/Appliances[A]	217			76			6,500,000		
2005/Residential[B]	117			104			6,890,000		
2005/Nonresidential[B]	368			107			300,000		
2006/2007/Appliances[C]	526			162			6,560,000		
Totals	**1422**			**689**			**21,700,000**		
Attributable to Program		*% of Code Savings*	*% Statewide Utility Goal*		*% of Code Savings*	*% Statewide Utility Goal*		*% of Code Savings*	*% Statewide Utility Goal*
2001/Residential[A]	21	16%	1%	29	15%	2%	150,000	19%	0%
2001/Nonresidential[A]	26	41%	1%	16	39%	1%	280,000	43%	0%
2001/Appliances[A]	74	34%	4%	29	38%	2%	1,760,000	27%	2%
2005/Residential[B]	83	71%	4%	41	39%	3%	2,900,000	42%	4%
2005/Nonresidential[B]	80	22%	4%	36	33%	3%	1,030,000	---	1%
2006/2007/Appliances[D]	158	30%[4]	8%	49	30%[4]	4%	1,970,000	30%[4]	3%
Totals	**445**	**31%**	**22%**	**200**	**29%**	**17%**	**8,090,000**	**37%**	**11%**
Statewide Savings Goals (for 2006)[E]	**2,032**			**1,199**			**72,000,000**		

[A]Heschong Mahone Group, Inc., 2001. Note that these are only single year numbers, and do not reflect the fact that five years' of new buildings will be online in 2006. They, therefore, greatly understate the expected savings from the 2001 cycle.

[B]ADM Associates, 2004.

[C]Energy Solutions, 2005. Preliminary numbers. Note that these estimates are not in full agreement with those of the CEC staff.

[D]To date, no independent verification of C&S program allocation of savings has been done. This table arbitrarily, and conservatively, allocates 30% of total savings to the C&S program for illustrative purposes.

[E]CPUC Decision 04-09-060 September 23, 2004, Interim Opinion: Energy Savings Goals for Program Year 2006 and Beyond, Table 1E

Figure 1: Estimates of C&S Program Savings – Single Year 2006 Estimates

The following figures, excerpted from most recent study of C&S program savings estimates for appliance standards (Energy Solutions, et al, 2005), gives an indication of the magnitudes of those savings for the different standards that were adopted in 2004. The estimated savings are presented in Figure 2 (energy savings) and Figure 3 (demand reductions)[4]. Many of these new appliance standards will not actually take effect until later years, and some produce more stringent efficiency levels in later years[5]. Those later year savings aren't reflected in the 2006 year number included above in Figure 1. The legend of the graph, excerpted from the Energy Solutions report, may be hard to read in its details, but it nevertheless shows that there are actually numerous appliances treated by this cycle of appliance standards, and that their individual savings rates change over time.

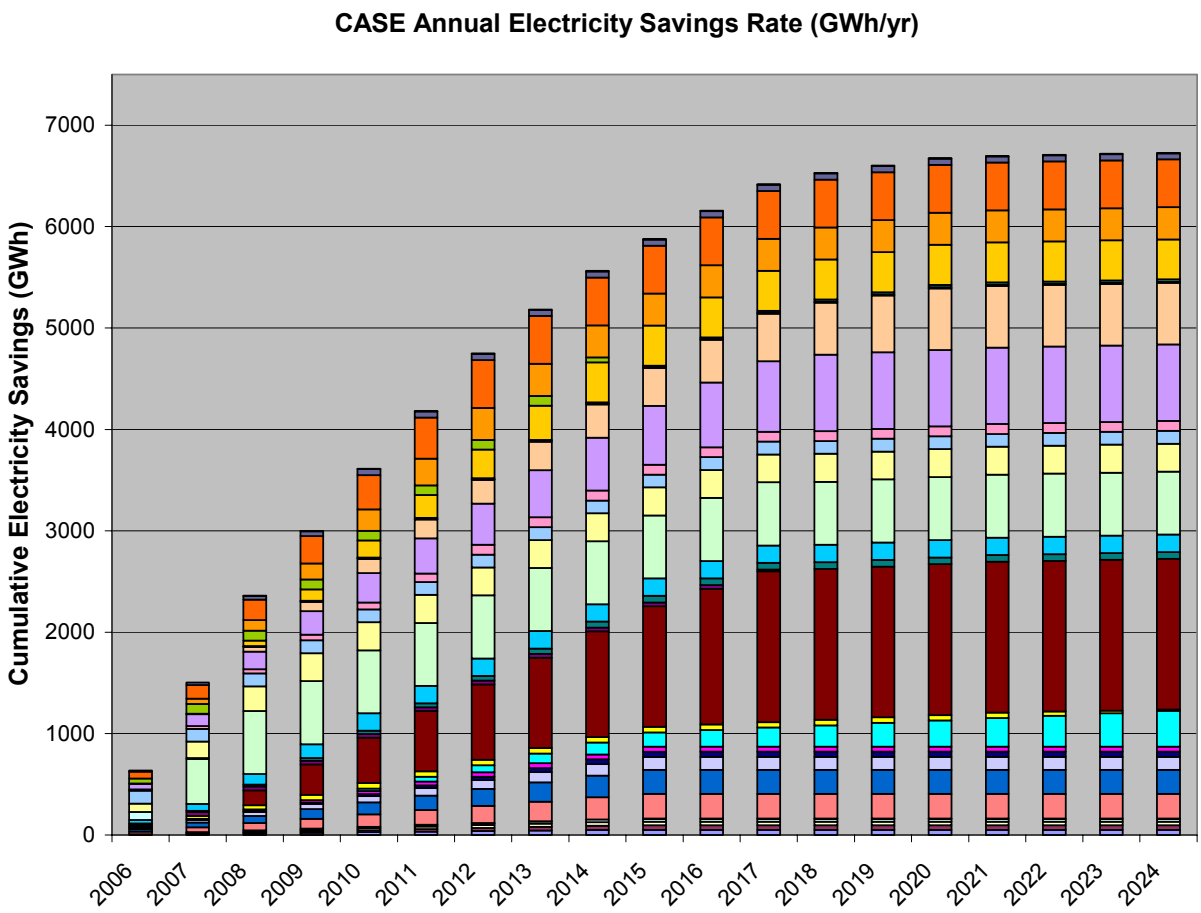

Figure 2: 2006/2007 Cycle - Appliance Standards Savings Estimates (GWh/yr)

[4] The individual color bands in each column represent different appliance standards adopted; the details are unimportant for the purposes of this paper.

[5] The savings curves are shown to level off, probably due to an assumption that the Standards don't save more energy after the end of the useful life of appliances regulated in the first year of the Standards; CEC staff does not agree with this concept. A formal evaluation study of this program will have to address this disagreement.

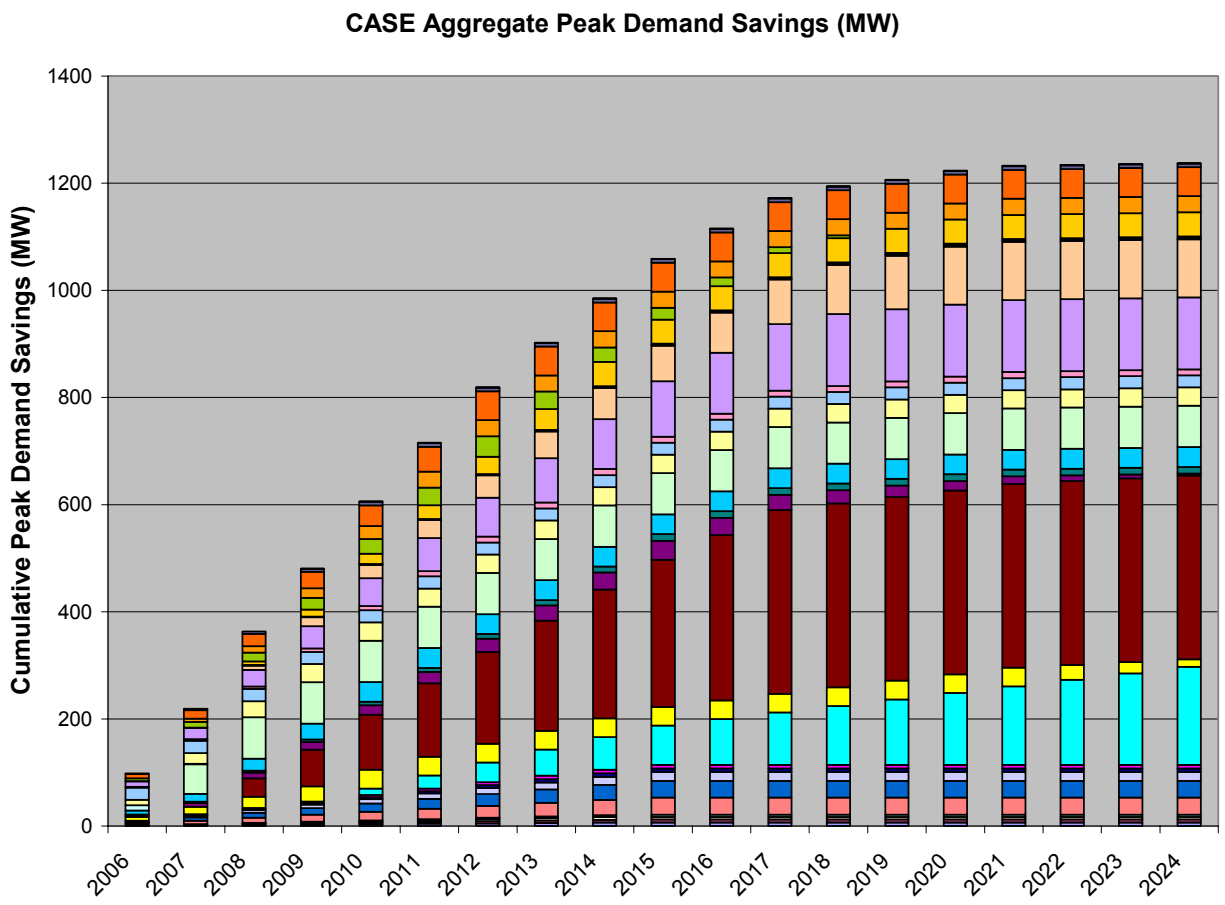

Figure 3: 2006/2007 Cycle - Appliance Standards Demand Reduction Estimates (MW)

There are a number of significant issues that must be addressed in developing reliable estimates of energy savings from standards. These are discussed individually, along with recommendations for how these estimates should be developed in the future.

- **Engineering Estimates** - Most of the issues with engineering estimates are common to any energy efficiency program, not just to standards. The primary difference for standards estimates, is that the savings must be estimated for a broad population of unknown buildings, rather than for a known set of individual buildings the way they would be in a retrofit situation.
- **Estimates of Market Size and Penetration** - An accurate estimate of the statewide energy savings attributable to an individual standards measure, whether it be a building measure or an appliance, depends on how large is the market penetration of the measure. The estimated savings will also be affected by the state of measure acceptance at the time it is adopted into standards.
- **Differences in Standards Implementation** – Appliance standards ban the sale of less efficient equipment within California, and they are enforced on the manufacturers and distributors, so builders cannot buy appliances that are less efficient than the standards. Building standards are different in that they set overall building performance budgets and allow trade-offs.
- **Difficulty of Estimating User Behavior** - Measure savings can be highly variable depending on the usage behavior of the building occupants. Energy savings from standards, therefore, must be based on a good understanding of real occupant behavior across the population.

The attribution of a portion of the statewide savings to the utility C&S program can be difficult to determine. Two different methods were developed in the HMG 2001 and the ADM 2004 studies, and neither has been thoroughly vetted by the evaluation community. The HMG methodology broke the adoption process into ten steps for each of the standards measures, and estimated the influence of the C&S program on each of those steps based on the expert opinions of the stakeholders and participants. A combined influence factor was then derived for each standards measure, and applied to the savings estimates to determine the magnitude of savings attributable to the program for each measure. The ADM methodology simply assigned the savings from some measures to the C&S program, corresponding to the measures for which the program made the greatest contributions toward adoption. The HMG methodology was the more thorough, but some have questioned its subjective nature and asked whether it would be repeatable or give consistent results. The ADM methodology was the simpler, but some have questioned whether it properly accounts for the role of the CEC in the adoption of measures, or for the role of the program in helping other measures be adopted. There is a need for further development of protocols that will address the particular challenges of attribution for C&S programs. We recommend that future attribution studies have the following attributes:

- Studies should be done by independent evaluators who are not directly involved in the standards-setting process.
- Studies should begin while the standards process is still underway, so that evaluators can observe first-hand how C&S program participation helps in the adoption process.
- Evaluators should be selected for their knowledge and experience with standards development processes, and their ability to develop and administer a clear and defensible investigative methodology.
- Evaluators should have the technical expertise and resources to develop independent estimates of future standards savings in a way that will facilitate true-ups of the estimates.

Lifetime Savings Estimates

In the previous section, we discussed how the basic estimates of energy savings can be done, and how to attribute to the C&S program its portion of those savings. In this section, we address the question of how to spread those savings over time. Standards savings are different from those of a simple retrofit, say a compact fluorescent lamp (CFL) trade-out, because the standards savings begin to "show up" in buildings as they are built subject to the standards. Likewise appliance standards savings begin to show up as new equipment purchases take place. Unlike a CFL trade-out, which is a one-time occurrence, standards improvements tend to be permanent. Once the standards are in place, they will govern new efficiency purchases every year into the future, so new savings will be realized every year, and the savings will accumulate over time. We present a definition of the *Net Effects Lifetime* and derive a recommended method to calculate it.

> Definition: ***Net Effects Lifetime*** is the period of time over which the energy impacts caused by the C&S program provide an energy saving effect in the market that would not have occurred in the absence of the program's efforts.

For programs that change standards, the change is typically placed in the market for as long as the standards are in effect. Even when new standards are adopted they seldom undo previous standards, allowing the energy savings to continue or grow (from the new standards) even after retrofits and remodeling efforts. It is seldom a market practice for renovations or retrofits to be implemented below the applicable standards. Essentially, technology and practices changes that are made as a result of a

standards change have a very long effective useful life. However, there are market conditions that erode the period over which energy savings can be counted. The following factors can account for these conditions

- The type of technologies/practices that are being used and its market penetration,
- The expected lifetime of the adopted technologies/practices ,
- The persistence of the use of the technologies/practices ,
- The amount of technology/practice adoption that would have occurred naturally in the market without the program,
- The period of time over which the change would have appeared in new standards if the C&S program had not contributed to its adoption, and
- The level of compliance with the new standards over time following adoption.

The graph in Figure 4 illustrates a method to combine these factors in a C&S impact evaluation to provide a defensible lifetime savings estimate. Figure 4 provides the total projected savings and the savings adjustment effects using the adjustment estimates associated with a reasonable scenario of market penetration for a given round of standards (in this case, it is based on the ADM 2004 study results, but it could apply to one of the other standards if different numbers were used). This approach estimates net effects at over 14 million MWh over 25 years for this example.

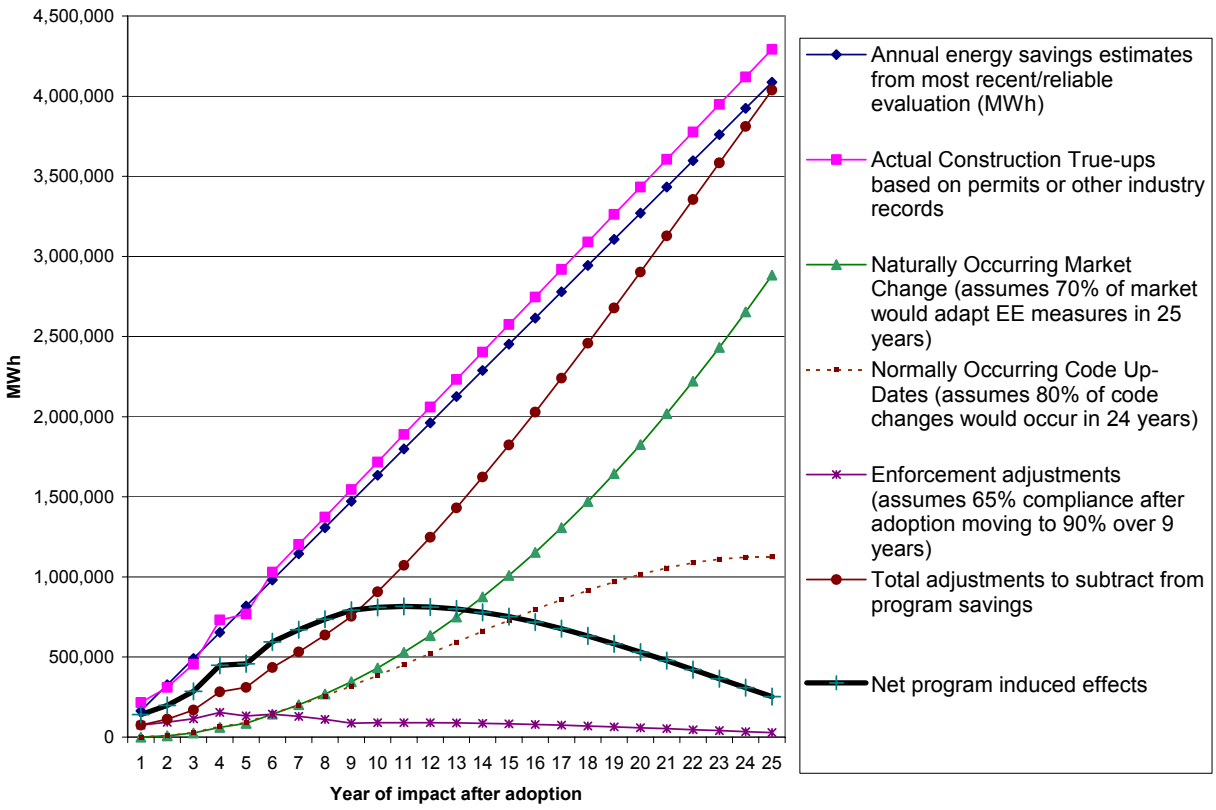

Figure 4: Savings Estimation Method Example – C&S Program Energy Impacts – MWh/year Saved

The starting point for this analysis is the "Annual energy savings estimates" (calculated as discussed in the previous section), which are then accumulated in a linear fashion over a 25 year time period. This straight line accumulation of savings is then adjusted based on "Actual Construction True-

ups" to better reflect actual installations. Next, the "Naturally Occurring Market Change" is estimated, as the rate at which the efficiency measure would be expected to enter the market on its own, absent a standards requirement. Then, the "Normally Occurring Code Updates" are estimated, as the rate the efficiency measure would be expected to be adopted into code, absent the efforts of the C&S program to accelerate adoption. Finally, the "Enforcement adjustments" are made, to reflect imperfect compliance with the standard; a lost savings. These adjustments are summed, and the sum subtracted from the program savings, to derive the "Net program induced effects" (the dark, hump-shaped curve in the middle of the graph). These net effects represent the expected values of the annual energy savings that can be attributed to the efforts of the C&S program. They gradually rise during the years following adoption of the standard, and then begin to taper off over time because we expect that some of the savings would begin to occur naturally, and so would no longer be attributed to the program.

As this is an illustrative example, the magnitudes and time frames for the savings are also merely illustrative. The savings for a given standard could be greater or lesser, and the expected rate of naturally occurring savings could arise sooner, later or never. Any of these changes would affect the height and breadth of the net effects curve, but it would still be essentially hump-shaped. Another important feature of this approach is that it only credits the C&S program with savings that would not have otherwise occurred, absent the program efforts; over time. This results in a result (for this example) that over 90% of the total savings expected to be realized statewide over the life of the standards (if accumulated without adjustments) are credited to factors other than the C&S program. This approach is conservative and acknowledges that the program is not the only force for energy efficiency.

This approach to deriving lifetime savings estimates for C&S program efforts is recommended for each standard as it is adopted. Over time, if new standards are adopted periodically, the savings would overlap in an additive manner. This is because the savings for each standard would be based on the incremental savings on top of the previous standard. Figure 5 provides an illustrative example of the energy savings from four sets of standards changes implemented over a 12-year period and the resulting accumulated energy savings. Again, the savings are estimated to demonstrate an assessment process, rather than to set the basis for a specific savings claim.

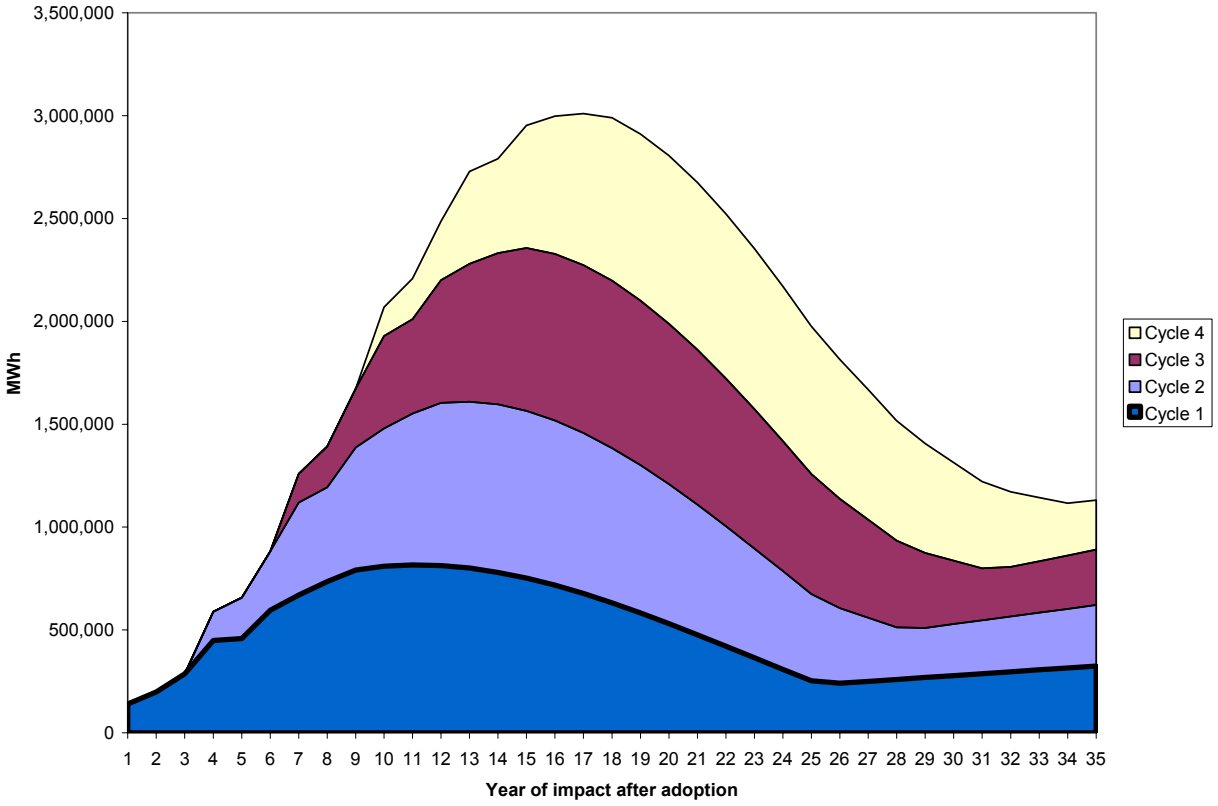

Figure 5: Expected Program Impacts from Four Consecutive Standards Cycles - – MWh/year Saved

From a program planner's or policymaker's perspective, it is important to account for both these benefits of the standards, as well as the costs to obtain those benefits. An examination of the budget came to $6,870,000 specifically spent by the C&S program on efforts to assess and recommend changes to the 2005 Title 24 standards, which correspond to the net effects estimated in Figure 4 example above. Figure 6 below shows the cost of saved energy as a function of time, based on utility costs only. Clearly, if a short period of time is used, the costs of energy savings will be higher than if a longer time period is used. This is because the initial cost to support standards changes is fixed, whereas the savings continue to accrue over time. The longer the accrual time, the lower the cost of saved energy[6]. This presentation demonstrates that the length of time considered in the model has very little effect on the results. Once the period of time moves past 10 years the annual change is small and does not significantly impact the results. The cost of energy savings are measured in hundredths of a cent per kWh.

It is important to recognize that this cost estimate does not include all of the costs of implementing standards, such as the cost to the building owner of measure installation. Therefore, these numbers are not comparable to TRC test values; they are more like program efficiency costs. Also, these numbers are simply in present dollars, and are not discounted for future time value of money. Nevertheless, we believe they make the point that C&S program investments are highly cost effective.

[6] The program cost used in this example does not include support for training or for enforcement. A more comprehensive program approach, and subsequent cost-effectiveness analysis, might well include such support as a way to improve the effectiveness of the standards and to maximize their savings. Other utility C&S program activities do, in fact, provide this type of support to the code community.

From a TRC perspective, the program would still be cost effective, because the measures adopted into the standards are all shown to be cost effective at the time of adoption.

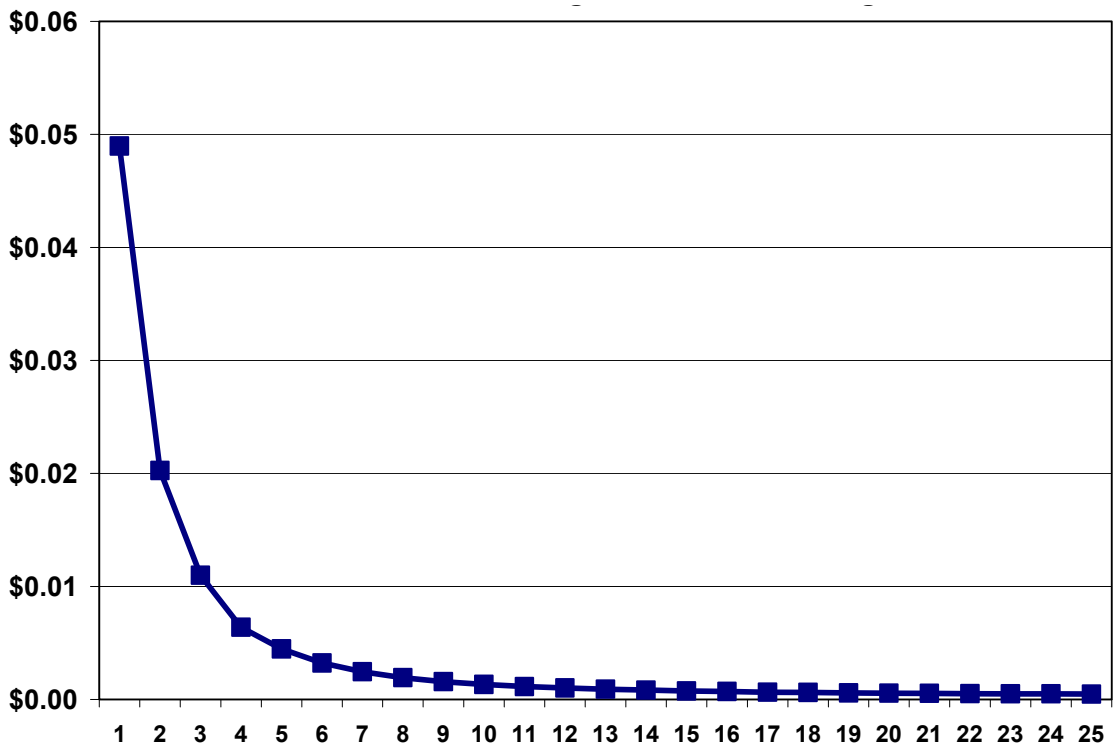

Figure 6: Example Cost of Saved Energy Over Time – $/kWh Saved

Verification of Savings

The preceding sections have discussed the issues of calculating and allocating savings from standards. This section discusses methods that could be used to verify actual savings following adoption of the standards.

These include assessments of how code options are adopted by the market, through a sample of buildings. Standards compliance rates should be verified in the field in a way that allows for quantifying actual energy savings. True-ups should consider verification of compliance rates, variability in as-built efficiencies, determination of actual construction activity, and trends in efficiency rates. Also, the larger economic factors affecting new construction should be considered.

In order for C&S programs to receive proper credit for the savings they achieve, attribution studies must be done to determine what fraction of statewide energy savings should be counted toward meeting savings goals.

Conclusions and Recommendations

Based on the preceding assessment of how C&S programs work, and how their energy savings and cost effectiveness can be estimated, the following recommendations are offered:

C&S programs should be integral to the portfolio of programs. They should not be "information-only" programs, and they should be seen as contributing substantial savings that could not otherwise be acquired through incentive or information mechanisms. In California, a policy has been established that C&S program savings should be counted for program efforts initiated in 2006 and beyond.

C&S programs produce important savings. Program savings are important because they reduce the need for more costly ratepayer investments in efficiency. Savings attributable to C&S program efforts can be properly counted toward meeting utility savings goals. This paper summarizes two approaches that have been used to estimate the attribution of savings; further refinement is warranted.

M&V issues for C&S programs build upon existing precedents. There are unique aspects to evaluating C&S programs, but existing M&V practices can be adapted to the task. The evaluation community, building upon the recommendations in this study, need to agree upon evaluation protocols that account for the unique characteristics of C&S programs. The requirements of procurement planning may necessitate greater precision in savings estimates than were previously developed. The potential savings are large, so even a simple estimate would be sufficient. Further studies are warranted to address this question of needed precision.

This paper derives and demonstrates a method for estimating the lifetime savings for standards. The method provides a realistic mechanism for counting savings over time, and could also be adapted to other long time-delay savings programs.

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