EVALUATION OF
2002 STATEWIDE
CODES AND STANDARDS
PROGRAM

Final Report

June 2004

Prepared for:

Southern California Edison Company
under Purchase Order K2033904
Managed by Heschong Mahone Group, Inc.

Prepared by:

ADM Associates, Inc.
3239 Ramos Circle
Sacramento, CA 95827
916-363-8383

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF TABLES, continued

EXECUTIVE SUMMARY

This report provides the results of the evaluation of the 2002 Statewide Codes and Standards Program. The objectives of the study were threefold:

- To evaluate the codes and standards program processes and program interactions with regulators, stakeholders, and the buildings-related communities;
- To evaluate program impacts and estimate attribution of impacts to C&S program activities; and
- To recommend ways to improve program effectiveness.

Information with which to address the first and third objectives were obtained through interviews conducted with 51 individuals representing interests that have a stake in the revision of the buildings and appliance energy efficiency standards and codes. The results of those interviews were used to examine (1) stakeholders' involvement in code revision process, (2) stakeholders' perceptions of CEC's code revision process and (3) stakeholders' perceptions of the impacts of the C&S Program on that process.

To address the second objective, savings estimates from other studies as well as estimates developed in this study were used to examine impacts of revisions to California's buildings and appliance efficiency standards that are attributable to the Statewide Codes and Standards Program. Code revisions that were adopted and for which the C&S Program provided support included the following:

- Time dependent valuation
- Residential proposals
  - Hardwired lighting
  - Duct improvements
  - Window replacement
  - Multifamily water heating
- Nonresidential proposals
  - Lighting controls under skylights
  - Ducts in existing commercial buildings
  - Cool roofs
  - Relocatable classrooms
  - Bi-level lighting control credits
  - Ducts and attics in light commercial buildings
  - Cooling tower applications

This study's estimates of the savings impacts of the code revisions supported by the Codes and Standards Program and adopted into the building and appliance efficiency codes through the 2005 code revision process of the California Energy Commission are shown in Table ES-1.

Table ES-1. Estimated Savings Impacts from Code Revisions Supported by Codes and Standards Program

	Estimates from This Study		
	Electricity (GWh)	***Peak (MW)***	***Natural Gas (Therms)***
Residential C&S code revisions	83.34	41.07	2,900,646
All 2005 residential code revisions	117.27	104.50	6,885,570
Percent from C&S code revisions	71%	39%	42%
Nonresidential C&S code revisions	80.15	35.56	1,035,000
All 2005 nonresidential code revisions	367.76	107.00	300,000
Percent from C&S code revisions	22%	33%	n/a
All C&S code revisions	163.49	76.63	3,935,646
All 2005 code revisions	485.03	211.50	7,185,570
Percent from C&S code revisions	34%	36%	55%

1. INTRODUCTION

Under contract with Southern California Edison Company (Edison), ADM Associates, Inc. (ADM) has conducted an evaluation of the 2002 Statewide Codes and Standards Program. Working with ADM as a consultant for this study was the New Buildings Institute. This document is the final report for the study.

1.1 BACKGROUND AND OBJECTIVES

The Codes and Standards (C&S) Program of the IOUs is a continuation of the effort begun in 1998 to identify technologies and practices that are ready for code adoption, to document their readiness for adoption in the buildings or appliances standards, and to advocate for their adoption. In addition, the C&S Program provides for informing and training market actors (building code officials, designers, builders, and affected facilities personnel) on the new code provisions when they are adopted.

The California Energy Commission has an established process in place whereby it assesses and, if appropriate, adopts proposed changes in the codes for buildings and appliances. The C&S Program operates within this existing context for making changes to California's buildings and appliance standards. Historically, most code change proposals were generated and developed by CEC staff. The C&S program provides substantial new resources to this process, in the form of technical expertise, research data and analysis.

The objectives for the evaluation of the 2002 Statewide Codes and Standards Program were threefold:

- To evaluate the codes and standards program processes and program interactions with regulators, stakeholders, and the buildings-related communities;
- To evaluate program impacts and estimate attribution of impacts to C&S program activities; and
- To recommend ways to improve program effectiveness.

1.2 OVERVIEW OF STUDY METHODOLOGY

Given the objectives for the study, there were two major aspects of the work on this project. The first aspect was to address the first and third objectives that pertain to the evaluation of the program processes and interactions and to use the results of that evaluation to recommend ways to improve program effectiveness. The second aspect was to evaluate program impacts and estimate attribution of impacts.

The methodology for the first aspect had the following steps:

- Collecting program reports for each of the utilities involved in administering codes and standards monies, for the past four years;

- Extracting and summarizing data on program activity, expenditures, program administration and other costs;
- Conducting in-depth interviews with C&S program staff, CEC staff, and representatives of stakeholder groups; and
- Preparing discussion of trends observed and other findings from the review of documents and the interviews.

When possible code improvements that are developed through the C&S Program are actually adopted into the buildings and appliances codes, energy savings should result from the code changes. The other aspect of the study was to review estimates of those energy savings and to estimate what percentage of the savings can be attributed to the C&S Program. The methodology for preparing these estimates made use of the volume of data submitted as part of the California Energy Commission's current process to revise the state buildings and appliance efficiency codes for 2005. Two major sources were used to guide the review of the savings estimates. The first source was the set of CASE study reports prepared by the IOUs and their contractors for proposed code revisions. The second source was the report prepared by Eley Associates for the California Energy Commission on the expected impacts of code revisions being accepted for the 2005 energy efficiency standards.

The procedures used in these various reports were examined to determine how the savings estimates were developed, to identify anomalous or inconsistent results, and to determine whether the procedures used for the estimation need to be modified. Code change proposals for which additional information was needed or for which energy savings need to be re-estimated were identified.

In work related to the AB970 revision of the building standards, the Heschong Mahone Group developed a methodology for attributing savings from code changes to the C&S Program.[1] The use of this methodology as a method for attributing savings was reviewed. In addition, data submitted for the CEC's code development process were used in an analytical framework to analyze how the support provided by the C&S Program enhanced the probabilities that a proposed code improvement would pass through the various stages of the code revision process into final inclusion in the code.

1.3 ORGANIZATION OF REPORT

This report is organized as follows.

- Chapter 2 discusses the code revision process and the role of the C&S Program in that process. This discussion addresses the effectiveness of C&S support activities, based on information gathered through interviews with stakeholders and regulators.

[1] Heschong Mahone Group, *CA IOU Codes and Standards Earnings Claims Framework: Final Report*, Report prepared for Pacific Gas and Electric Company, October 2001.

- Chapter 3 discusses the results of an analysis to attribute savings to C&S Program efforts.
- Chapter 4 discusses the estimation of energy savings that are expected to result from code changes influenced by the C&S Program.
- Chapter 5 summarizes and discusses the results of the study.
- Appendix A provides discussions of different approaches to attributing savings to the C&S Program.
- Appendix B provides an annotated bibliography of papers and reports related to the research effort.
- Appendix C contains copies of the guides used in interviewing C&S Program Managers/staff, CEC staff, and stakeholders in the code revision process.

2. IMPACT OF C&S PROGRAM ON CODE REVISION PROCESS

Two of the objectives for the evaluation of the 2002 Statewide Codes and Standards Program were (1) to evaluate the codes and standards program processes and program interactions with regulators, stakeholders, and the buildings-related communities and (2) to recommend ways to improve program effectiveness. The results of this aspect of the evaluation effort are presented and discussed in this chapter.

This chapter is organized as follows. Section 2.2 discusses principles for guiding a standards setting procedure. Section 2.3 discusses the process followed in California to develop building and appliance energy efficiency standards and codes. Section 2.4 discusses how the C&S Program has impacted the California code revision process. Section 2.5 provides suggestions for improving the C&S Program and its impact on the code revision process.

2.1 GENERAL PRINCIPLES AND CRITERIA FOR STANDARDS

As background to considering the impacts of the Codes and Standards Program on the process by which building and appliance efficiency standards are developed, it is useful to begin by setting out an understanding of the general principles and criteria that should be followed during the process.

The process to be followed in setting standards has been a topic of interest since the early part of the 20th century, as evidenced by the founding of the American National Standards Institute (ANSI) in 1918. ANSI acts as an administrator and coordinator of the voluntary standardization system followed by the private sector in the United States. In that role, ANSI has developed a set of procedures that it recommends that standards developers follow. In order to maintain ANSI accreditation, standards developers are required to adhere consistently to these procedures and requirements.

Although developed for processes whereby private industry develops voluntary standards, ANSI's procedures also provide a benchmark against which to gauge public sector standards development as well. Most importantly, ANSI stresses that the process by which standards are developed be open and fair, ensuring that all interested and affected parties have an opportunity to participate.

ANSI believes that due process requires that standards be developed in an environment that is equitable, accessible and responsive to the requirements of various stakeholders. The process by which standards are developed is expected to include the following:

- consensus on any proposed standard by "consensus body" that includes representatives from materially affected and interested parties;
- broad-based public review and comment on draft standards;

- consideration of and response to comments submitted not only by members of the relevant consensus body but also by public review commenters; and
- incorporation of approved changes into a draft standard.

2.2 PROCESS USED IN CALIFORNIA TO DEVELOP BUILDING AND APPLIANCE ENERGY EFFICIENCY STANDARDS AND CODES

In California, building energy efficiency standards are embodied in Title 24 of the California Code of Regulations, while appliance standards are embodied in Title 20. Although the California Building Standards Commission is charged with administering the California Building Standards Code, the California Energy Commission is the cognizant agency for developing and adopting the building and appliance efficiency standards that go into the code.

Because the CEC is a regulatory agency charged by the legislature through the Warren Alquist Act to adopt standards that are cost effective, it is not compelled to follow an ANSI-style consensus process. Although this means they can adopt code provisions that would not achieve consensus, in the ANSI sense, the process the Commission follows does seek to build substantial buy-in from affected stakeholder groups. This is partly for practical reasons (e.g., objectionable provisions would be hard to enforce). There are also political reasons (e.g., not alienating powerful stakeholders).

The first version of Title-24 was adopted in 1978. The CEC has agreed with the building community not to update the standard more often than once every three years, although in practice the time period for revisions has been from three to five years. The process that the CEC uses in revising the standards has of course evolved over time. However, there are some basic elements to the process.

- The CEC staff have developed extensive mailing lists over time of people who have interest or involvement in the code revision process. The staff use these lists to alert and inform stakeholders about the code revision process.
- The CEC generally hires a consultant team to contribute technical work that evaluates and supports any proposed code revisions.
- The work of the CEC staff and its consultants are introduced for public review and comment primarily through numerous public workshops. Through these workshops, the CEC endeavors to involve builders, architects, engineers, and environmental interest groups in the development of the building or appliance energy efficiency standards.

The major objectives addressed in the 2005 code revision process were as follows:

- Respond to California's energy crisis to reduce energy bills, increase the reliability of the energy system, and contribute to an improvement in California's economic condition;
- Respond to the AB 970 (Statutes of 2000) emergency legislation to adopt and implement updated and cost-effective building energy efficiency standards to ensure maximum

reductions in wasteful, uneconomic, inefficient or unnecessary consumption of electricity at the earliest feasible date;

- Respond to the SB 5X (Statutes of 2001) emergency legislation to adopt energy efficiency building standards for outdoor lighting;
- Pursue major objectives of the CEC, including adaptation of the Standards to emphasize energy efficiency measures that save energy at peak periods and seasons; encourage improvements in the quality of installation of energy efficiency measures, adopt requirements based on recent public funded building science research, and collaborate with the California utilities to coordinate Standards updates with public funded market incentives programs that have demonstrated that specific technologies are appropriate for incorporation into Standards.

2.3 IMPACT OF C&S PROGRAM ON CODE REVISION PROCESS

The impact of the Codes and Standards Program on the process by which the California Energy Commission revises the building and appliance energy efficiency standards is addressed in this section. The method used to collect information regarding those impacts is discussed first, followed by a discussion of the impacts.

2.3.1 Methods Used to Collect Information

To collect the information with which to gauge the impact of the Codes and Standards Program on the process by which building and appliance energy efficiency standards are revised, interviews were conducted with various parties involved in the standards setting and code revision processes.

- One set of interviews was conducted with staff of the California Energy Commission responsible for directing the code revision process. These interviews were directed toward determining the perceptions of the CEC staff on how the C&S Program has influenced the process by which they change standards and codes. A copy of the guide used in interviewing CEC staff is provided in Appendix B.
- Interviews were conducted with C&S program staff and consultants involved in preparation of CASE reports.
- Interviews were also conducted with various stakeholders who have an interest in the code revision process. Individuals interviewed were selected from among those who had actively participated in the CEC's 2005 code revision process. Included among those interviewed were representatives of the following groups of stakeholders:
  - Manufacturers:
  - Manufacturers trade associations:
  - Construction industry firms:
  - Construction industry trade associations:
  - Construction industry consultants:

A total of 51 interviews were conducted, spread among representatives of the various groups.

In general, the organizing theme used for interviewing the selected stakeholder representatives was to determine what factors they think are most important for making code changes and the degree to which they think the C&S Program affects the probability that proposed code improvements are actually included in the codes. This included looking for evidence regarding code changes that may have been suggested through an IOU C&S process and developed by others and code changes that may have been suggested and developed by others but that were significantly affected by input from the IOU C&S team or by research done by one of the IOUs.

The interviews were conducted using an interview guide that addressed a range of topics related to their involvement in the CEC code revision process and to their perceptions of the impact of the C&S Program on that process. A copy of the guide used in interviewing stakeholders is provided in Appendix B. All interviews were conducted by telephone. Interviewees were given assurances that the discussions were confidential and that no comments they made would be attributed to a specific individual.

2.3.2 Results of Stakeholder Interviews

As noted above, interviews were completed with 51 individuals representing interests that have a stake in the revision of the buildings and appliance energy efficiency standards and codes. The results of those interviews are summarized here with respect to (1) involvement in code revision process, (2) perceptions of CEC's code revision process and (3) perceptions of the impacts of the C&S Program on that process.

2.3.2.1 Involvement in CEC's Code Revision Process

To start the stakeholder interviews, interviewees were asked to characterize whether their involvement in the CEC's code revision process could be regarded as primarily proactive or primarily reactive. With some notable exceptions, most stakeholders characterized their involvement as reactive. That is, they reviewed proposed code changes but generally were not active themselves in developing and submitting proposals for changes.

In terms of proactive involvement in the code revision process there are three main groups.

- CEC and its contractors;
- C&S Program and its contractors; and
- CBIA and its contractors;

Obviously, the CEC along with its contractors develop code enhancement proposals. However, the California Building Industries Association (CBIA) is also active in funding energy analyses of code revision proposals for the residential sector and provides the results of those analyses to CEC staff. Moreover, in cooperation with the Natural Resources Defense Council (NRDC), CBIA has hosted "key player" workshops where staff from CBIA, NRDC and other key players review potential code revision proposals for their feasibility and efficacy. In effect, the process used by CBIA in some respects parallels that used by the C&S Program.

Other parties also develop and propose code enhancements, but not with the same level of effort as the CEC, the C&S Program, and the CBIA. Examples include the California Association of Building Energy Consultants (CABEC) and product manufacturers (e.g., WattStopper).

2.3.2.2 Perceptions of CEC's Code Revision Process

Each person interviewed was asked a set of questions about their perceptions of the CEC's code revision process, with particular reference to the process underway for developing code revisions that will take effect in 2005.

In general, those interviewed felt that the CEC code revision process was open. However, most also felt that the process was time-consuming, given the volume of material to be reviewed and the number of workshops being held. Scheduling within the process also was perceived as creating difficulties in that the time allowed for reviewing materials was often too short. Some interviewees pointed out that their staff did not always have time available for reviewing the materials within the shortened time frames allowed. The scheduling of workshops could also make it more difficult to participate for parties who had considerable distance to travel (e.g., from southern California or from the Midwest or East Coast).

Over time, the CEC has formalized the process for making code revisions. Nevertheless, perceptions of the process appear to be colored by the amount of experience that an individual or organization has had with the code revision process. Those stakeholders who have been participating in the process over several code revision cycles generally found the process to be relatively open and transparent. They had worked with CEC staff in previous cycles and were aware of how and when to approach staff with suggestions. In some sense, they are aware of and can work through the "shadow" code revision process that parallels the formal process.

An example of how a stakeholder has been able to work with the CEC staff on the code revision process is provided by looking at the role that the California Building Industries Association (CBIA) has taken. CBIA has been involved in the code setting process since the 1970's. Over time, however, CBIA has gone from playing a role that was somewhat adversarial to the CEC to one that has them being involved in the development of proposed code revisions. In the mid 1990's, CBIA began approaching CEC staff before the formal code revision process began and started working with the staff on reviewing and developing code revision proposals. The goal was to identify what code revisions were workable for builders and which ones were not. As part of this process, CBIA now funds energy analyses of code revision proposals and provides the results of those analyses to CEC staff. Moreover, in cooperation with the Natural Resources Defense Council (NRDC), CBIA has hosted "key player" workshops where staff from CBIA, NRDC and other key players review potential code revision proposals for their feasibility and efficacy.

In contrast, there were parties whose first participation in the code revision process came with the 2005 code revision cycle. Examples of such parties included those affected by proposed standards for outdoor lighting or for relocatable classrooms. Those stakeholders participating in the code revision process for the first time were somewhat more perplexed about the process.

They did not have the experience in working with CEC staff or other stakeholders and found the formal process to be less open and transparent. For some of those first participating in the process, just learning that their business might be affected by code revisions was a hurdle. Several interviewees noted that they had learned only by happenstance of proposed code revisions that might affect their business.

2.3.2.3 Perceptions of Impacts of C&S Program on CEC's Code Revision Process

Because the C&S Program is funded through public goods charges, it is useful to examine how the program has impacted the participation of other stakeholders in the process that do not receive such funding. The interviews of stakeholders were designed to provide the information for assessing this impact.

Although other stakeholders recognized the participation of the utilities in the process, it was not always explicitly recognized that this participation was coming through the C&S Program. Even some long-time participants in the process did not recognize that utility presentations at workshops were generally based on work they had performed through the C&S Program.

Interviewees saw both positives and negatives in utility participation. Major observations on the positive side included the following.

- CEC staff indicated that the utilities' work through the C&S Program allowed looking at more code revisions and looking at some revisions earlier than otherwise would have been possible. Thus, some revisions could be adopted in an earlier cycle than otherwise would be the case, allowing the stream of savings that would be realized to begin earlier in time.
- Because utilities are somewhat less constrained in their procurement processes than the CEC, they were better able to pick experts to conduct studies of particular types of measures that might be more specialized in nature (e.g., cool roofs).
- CEC staff perceived that utility participation in the code revision process affected the involvement of other stakeholders in that the quality of the work supported through the C&S Program raised the threshold for participation in the process. Moreover, CEC staff felt that other stakeholders participating in the process also had to become more constructive because of the technical quality of the work supported through the C&S Program.

There were also some negative observations about the participation of the utilities in the process.

- Utility participation meant that the volume of code revision proposals to review and digest was greater, imposing an additional burden on other stakeholders, particularly those with limited time and staff. For example, even the CBIA, which explicitly budgets for conducting analyses of code revision proposals, remarked that the volume of proposals for the 2005 cycle was somewhat intimidating at first.
- Proposals made through the C&S Program were sometimes perceived as being somewhat aggressive in pushing for the inclusion of some energy efficiency measures in the standards. This aggressiveness was perceived as taking several forms.

- First, some code provisions were regarded as severely hampering a particular technology's role in the marketplace. For example, manufacturers of metal roofs were concerned about the effects that the code revision proposals for cool roofs would have on their product.
- Second, some code revision proposals were perceived as not being fully attuned to the realities of the technology when actually applied. An example cited here (e.g., by CBIA) was that of the proposed requirements for residential lighting. The feeling expressed was that some of the lighting technology that would be needed to meet the code requirements did not yet have significant market penetration. It was felt that advance efforts were needed to make homebuilders more conversant and comfortable with the lighting technologies that they would need to use to meet the code requirements. Accordingly, CEC is proposing to promote use of such technology by providing compliance option credits before the prescriptive requirements take effect.

2.4 SUGGESTIONS FOR IMPROVING C&S PROGRAM AND ITS IMPACTS

Several suggestions for improving the C&S Program emerged from the interviews of stakeholders. Those suggestions are presented and discussed here.

Improvements for the C&S Program might be identified by considering more closely how the program acts in harmony with or in conflict to the code revision activities of other groups. As noted above, the participants in the code revision process can be divided into at least four major groups:

- CEC and its contractors;
- C&S Program and its contractors;
- CBIA and its contractors; and
- Other parties (e.g., consultants, manufacturers).

In some respects, the CEC, the C&S Program, and the CBIA (and their contractors) are the "inside" players for the code revision process. For other parties, however, particularly stakeholders who are new to the code revision process, the formal process does not always appear to be open and transparent. It is of course true that such stakeholders must take some burden themselves in learning how the process works. However, some assistance to help them might be warranted. Examples of such assistance that were mentioned during the interviews included the following.

- Several interviewees noted that it would be helpful if industry could be more involved in work that utilities go through in proposing and vetting possible revisions to the code. They felt that their understanding of their own industries could be helpful to the utilities and their consultants in making sure that code revisions being developed would be consistent with industry practices and circumstances.

- Interviewees who were in the business of manufacturing products for the energy efficiency market indicated that they would look favorably on being provided with assistance with testing through the program. These stakeholders noted that testing of their products by an independent body provided their customers with better assurance about the products. However, they also noted that the cost of testing was often onerous and that assistance in this area would therefore be welcome.
- Although the utilities already provide some assistance in training builders and contractors on the Title 24 code, some interviewees mentioned that they felt that there was room for expanding this assistance. In part, such training assistance would address the fact that some of the 2005 code revisions affect stakeholders or sectors that have previously not been affected. For example, the 2005 code revisions have more impact on existing buildings than previous revisions. To the extent that builders and contractors for this segment of the market are different from those active in the new construction segments, assistance could be provided to them in coming up to speed on code requirements. This also applies to other industry segments (e.g., outdoor lighting firms, relocatable classroom manufacturers) that are only now being affected by the Title 24 code.

3. ATTRIBUTING IMPACTS OF C&S PROGRAM

This chapter discusses the issues that arise in assessing attributing the impacts of the C&S Program (Section 3.1) and provides the results of the attribution approach actually used (Section 3.2). Appendix A provides a discussion of other attribution methodologies that were examined but not used for this study.

3.1 ISSUES IN ASSESSING IMPACTS OF POLICY-ORIENTED RESEARCH

The C&S Program is characterized as an information-only program. A major thrust of the program is to identify technologies and practices that are ready for code adoption, to document their readiness for adoption in the buildings or appliances standards, and to advocate for their adoption. In addition, the C&S Program provides for informing and training market actors (building code officials, designers, builders, and affected facilities personnel) on the new code provisions when they are adopted.

Because the C&S Program is in large part directed toward influencing governmental policy decisions, the methodologies for assessing and attributing the impacts of the program differ from those used in evaluating other types of energy efficiency program. This is due to the generally acknowledged perception that the linkage to outcomes is less direct for policy-oriented research than for energy efficiency implementation programs. Various methodologies for evaluating policy-oriented research such as is conducted by the C&S Program were therefore identified through a literature review and their applicability to the evaluation of the program was assessed.

The review of the literature on the impacts of policy research on policy making reveals that methodologies for evaluating the impact of research on policy choices and policy outcomes are not well-developed. However, the literature does suggest that the impacts of policy-oriented research might be assessed by considering the ways in which the knowledge produced by the research is used.

- A first use of research knowledge in policy making is when research findings are used directly to design a policy. This use of research knowledge can be evaluated by examining how specific research is directly linked to specific policy decisions.
- A second use of research knowledge is to justify a course of action already decided on (i.e., advocacy research).
- A third use is when research findings lead to a gradual change in the framing and understanding of an issue for which policy needs to be formulated. The way a problem issued is defined often determines how it will be addressed. In this context, research has been argued to serve an ‘enlightenment’ function in getting people to see new problems or to see old ones in new ways.

The research produced through the C&S Program has been used primarily in the first and third ways. That is, it has been used to directly guide policy decisions on which code change provisions to adopt and also to provide new information that can better inform the development of energy efficiency standards and codes. Among the utilities, however, there were differences in the relative emphasis that they gave to producing research through the C&S Program for the different uses. For example, PG&E gave more emphasis to research that could be used directly to define specific code change provisions. SCE, on the other hand, provided support through the C&S Program to activities that can be considered to be aspects of the "enlightenment" function of the research. In a sense, the distinction is similar to that often made between "applied" research and "basic" research. While the results of applied research can often be tied to specific outcomes, basic research produces results that are more generally supportive of the research environment.

Although it is generally argued that the complexity of the policy process and the general nature of much policy research makes it difficult to attribute policy decisions or policy outcomes to specific research findings, the process by which code change provisions were developed for the 2005 update to the Title 24 code and the approach that PG&E took for its C&S Program allowed this attribution to be made fairly directly. The actual attribution procedure used is discussed in Section 3.2, while other attribution methodologies that were examined but not used are discussed in Appendix A.

While the attribution procedure discussed in Section 3.2 provides evidence on how C&S research sponsored by PG&E directly influenced the adoption of specific code change provisions, it should not be overlooked that the C&S Programs of other utilities were more oriented toward producing research that served the more diffuse "enlightenment" function. Thus, although the research findings produced through the other utilities' C&S Programs were not as often directly employed in support of specific code change provisions, they still contributed to advancing the knowledge on technologies and practices that might become topics of code changes in the future.

3.2 EMPIRICAL ATTRIBUTION APPROACH FOR C&S PROGRAM

In the cycle for the 2005 code revision process, the California Energy Commission (CEC) was able to use a formal process for identifying, screening, and adopting code changes. Because of this process, individual stakeholders could and did take "ownership" of particular code revision proposals by developing the proposal and the materials to support inclusion of that proposal in the code. There was of course some collective work among the CEC staff and various stakeholders, but this collective work was not as heavy as during the preceding AB970 proceedings.

Because of the formality of the 2005 code revision process, a set of data was produced that could be used empirically to determine the contribution of the C&S Program to the adoption of code improvements. In particular, as part of the process for revising the standards, the CEC received 271 templates and ideas that proposed code changes. Analysis of this information from the 2005 code revision process indicated that support through the C&S Program had at least two effects.

- One effect was that a proposed code revision that received C&S Program support had a higher probability of being accepted for further analysis.
- A second effect was that a proposed code revision that received C&S Program support and that was accepted for analysis had a higher probability of being recommended for inclusion in the code.

From the 271 proposed changes, the Commission staff selected the 28 ideas listed in Table 3-1 for further analysis. (Some of these 28 represent combinations of multiple suggestions out of the 271.)

Table 3-1. Proposals for 2005 Code Changes Selected for Further Study by CEC

No.	Sponsor	Proposal
1	CEC, IOU	Time Dependent Valuation
2	CEC	Residential Air Conditioner Sizing
3	CEC	Residential Construction Quality
4	CEC	Residential Duct Systems
5	IOU	Improvements for Existing Homes
6	CEC	Performance Verification of Nonresidential Systems and Equipment
7	CEC	Residential Fenestration
8	IOU	Water Heating in Multi-Family
9	CEC	Water Heating Distribution Loss Performance Improvement Options
10	Other	Revise Mandatory Minimum Duct Insulation to R-8 for Nonresidential Occupancies
11	IOU	Improvements for Existing Light Commercial Buildings
12	CEC	Lighting Power Allowances - Complete Building Method
13	CEC	Lighting Power Allowances - Area Category Method
14	IOU	Demand Control Ventilation
15	IOU	Inclusion of Cool Roofs in Title 24
16	Other	Automatic Controls to Shed Load
17	CEC	Air Side Economizers
18	CEC	Hydronic System Measures
19	Other	Electrically Commutated Motors for HVAC Terminal Unit Fans
20	IOU	Cooling Towers
21	IOU	Lighting Controls Under Skylights
22	CEC	Simplification of Tailored Method
23	CEC	Size Threshold for VAV Fan Controls
24	IOU	Staged Volume Fan Control
25	IOU	Hardwired Lighting
26	IOU	Modular Classrooms
27	Other	Revise Prescriptive Envelope Requirements for Nonresidential Occupancies
28	CEC	T-Bar Ceilings

Consider first how the type of sponsorship affected the probability that one of the 271 proposed revisions submitted to the CEC was one of the 28 selected by the CEC for further study. The numbers of proposals from different sponsors are shown in Table 3-2. CEC alone sponsored 47 of the code revision proposals, plus 1 in association with PG&E. Three utilities (i.e., PG&E, SCE, and SoCalGas) sponsored 27 code revision proposals through the C&S Program.

Table 3-2. Number of Code Revision Proposals from Different Sponsors

Sponsor	***Total***
CEC	47
CEC, PG&E	1
PG&E	20
SCE	6
SoCalGas	1
J.J. Hirsch	12
WattStopper	10
NAIMA	8
Cardinal Glass	7
Other	159
Total	271

Table 3-3 provides evidence as to how sponsorship of a code revision proposal affected the probability of the proposal being accepted for further study. As can be seen, higher proportions of the proposals sponsored by either the CEC or by one of the utilities were accepted for study than were proposals submitted by other parties.

Table 3-3. Acceptance of Code Revision Proposals from Different Sponsors

Type of Sponsor	***Number of Proposals Submitted***	***Number of Proposals Accepted for Further Analysis***	***Percentage of Proposals Accepted for Further Analysis***
CEC	48*	14*	29.2%
Utilities	28*	11*	39.3%
Other	196	4	2.0%

*Includes proposal submitted jointly by CEC and PG&E.

There are some other factors besides the type of sponsorship that could affect whether a code revision proposal was accepted for further analysis.

- The CEC team and staff accepted some of the C&S code revision proposals submitted by utilities in an effort to ensure that resources were allocated to give the highest success probability for the highest number of code changes. For example, the proposal for hardwired residential lighting made by the utilities was accepted for further analysis. Had the utilities not made this proposal, however, the CEC would have gone ahead with its own proposal to further analyze lighting code revisions for the residential sector.
- Some of the CEC proposals were accepted because the CEC had made a commitment during the AB 970 Standards proceeding to address the proposed revision in the 2005 round of Standards changes.

Utility support was also crucial in moving code revision proposals from the study phase into active consideration for adoption. In particular, out of the 28 proposals that were accepted for further study, there were several industry-sponsored proposals that did not in actuality receive this further study because the industry sponsor did not feel capable of funding the required research.

The attribution of savings for C&S code revision proposals can be accomplished by considering the major proposals that were finally adopted into the code. That is, unless a code revision proposal was adopted into the code, no savings could be attributed to that proposal. For most of the code revision proposals that were accepted for detailed study for possible adoption, there was a relatively discernible demarcation as to which party was responsible for the work on a proposal. That is, the research that supported a particular code revision proposal could be traced and directly linked to a particular sponsor.

In particular, the major proposals that were adopted into Title 24 and for which the C&S Program provided support included the following:

- Time dependent valuation
- Residential proposals
  - Hardwired lighting
  - Duct improvements
  - Window replacement
  - Multifamily water heating
- Nonresidential proposals
  - Lighting controls under skylights
  - Ducts in existing commercial buildings
  - Cool roofs
  - Relocatable classrooms
  - Bi-level lighting control credits
  - Ducts and attics in light commercial buildings
  - Cooling tower applications

Moreover, savings that will result from the adoption of these code revisions can be attributed to the particular activities of PG&E in that the research for all of these major proposals for code revisions was supported by PG&E through its C&S Program.

4. ENERGY SAVINGS FROM CODE REVISIONS

This chapter presents and examines estimates of the energy savings projected to result from the code revisions that have been developed for implementation in 2005 and that can be attributed to the C&S Program. This chapter is organized as follows. Section 4.1 discusses the methodology used to examine the savings estimates. Section 4.2 discusses the savings that are expected to result from Time Dependent Valuation. Section 4.3 presents and discusses savings estimates for code revisions proposed for the residential sector. Section 4.4 presents and discusses savings estimates for code revisions proposed for the nonresidential sector. Section 4.5 summarizes the estimates of savings to be expected from the code revisions.

4.1 BACKGROUND FOR EXAMINING SAVINGS ESTIMATES

Estimates of the energy savings from the code changes being developed for implementation in 2005 have been prepared by Eley Associates as part of the *Impact Analysis* for the *2005 Update to the California Energy Efficiency Standards for Residential and Nonresidential Buildings.* The energy savings estimates presented in the Eley Associates *Impact Analysis* Report provided the referent point for the review of energy savings estimates for the code revisions that can be attributed to the C&S Program. The savings estimates are reproduced in Table 4-1. (Note that although Time Dependent Valuation was a major code revision for which the C&S Program provided support, estimates of the savings that will result from using TDV were not prepared for the impact report.)

Table 4-1. Savings Estimates from Impact Report for Proposed Changes to 2005 Energy Efficiency Standards Attributable to C&S Program

Sector/Code Revision	***Estimated Savings***		
	Electricity (GWh)	***Peak (MW)***	***Natural Gas (Therms)***
Residential			
Hardwired lighting	64.60	2.97	
Duct improvement	35.14	24.30	2,719,430
Window replacement	6.34	2.40	295,646
Multifamily water heating	0.0	0.0	1,500,000
Subtotal, Residential	*106.08*	*29.67*	*4,515,076*
Nonresidential			
Lighting controls under skylights	n/a	n/a	n/a
Ducts in existing commercial buildings	9.73	7.36	1,035,000
Cool roofs	14.60	9.50	n/a
Relocatable classrooms	3.10		n/a
Subtotal, Nonresidential	*27.43*	*16.86*	*1,035,000*
Total, Residential and Nonresidential	*133.51*	*46.53*	*5,550,076*

Table 4-1 does not include savings estimates for three nonresidential measures that were supported by the C&S Program and adopted into the code: bi-level lighting control credits, duct testing and sealing for new light commercial buildings, and cooling tower applications. The impact report prepared by Eley Associates did not report individual savings estimates for these measures, although their savings are included in the overall estimate of nonresidential savings.

Using the savings impacts that Eley Associates estimated in their impact report, Table 4-2 compares the savings attributable to code revisions supported by the C&S Program to the savings estimated for all 2005 code revisions. For the residential sector, code revisions supported by the C&S Program account for over three-fourths of the kWh savings estimated for all 2005 code revisions, for about a third of the kW reductions, and just over half of the therm savings. For the nonresidential sector, code revisions supported by the C&S Program account for about 8% of the kWh savings estimated for all 2005 code revisions and for about 19% of the kW reductions. They account for more than the overall therm savings because other revisions increased gas usage.

Table 4-2. Comparison of C&S Code Revision Savings to All 2005 Code Revision Savings Using Savings Impacts from Eley Associates' Impact Report

Sector	Estimated Savings		
	Electricity (GWh)	Peak (MW)	Natural Gas (Therms)
Residential C&S code revisions	106.08	29.67	4,515,076
All 2005 residential code revisions	140.01	93.10	8,500,000
Percent from C&S code revisions	76%	32%	53%
Nonresidential C&S code revisions	27.43	16.86	1,035,000
All 2005 nonresidential code revisions	338.20	88.30	300,000
Percent from C&S code revisions	8%	19%	
All C&S code revisions	133.51	46.53	5,550,076
All 2005 code revisions	478.21	181.40	8,800,000
Percent from C&S code revisions	28%	26%	63%

The various savings estimates reported in Table 4-1 were reviewed to identify (1) issues that may be associated with the data sources and with the procedures used to prepare the estimates and (2) any anomalous or inconsistent results. This included reviewing energy savings estimates included in CASE reports.

The results of the review are reported for each of the code change proposals that has been identified as needing additional information or for which energy savings should be re-estimated. Any inconsistencies found are described, additional data needs are identified, and, where applicable, modifications to the energy savings estimates have been suggested. Documentation has been prepared for each estimate that addresses (1) what the savings estimate is, (2) whether the methodology used for the calculation of the savings estimate was appropriate, (3) whether assumptions used were reasonable and appropriate, and (4) whether savings calculations were done correctly.

Several considerations arise when the savings estimates prepared by Eley Associates were examined. A first consideration pertains to the definition of baseline conditions. As is commonly recognized, savings from code changes are estimated by the difference between energy use under a set of baseline conditions and energy use under the conditions that result from the code changes. For any savings calculation, defining baseline conditions is a major consideration in determining the magnitude of the savings that are calculated.

There are two general ways in which baseline conditions can be defined:

- By using a specified energy code or standard; or
- By considering standard building practices.

In estimating savings from the proposed 2005 code changes, Eley Associates used both ways. For some code revisions (e.g., for changes in lighting power densities), savings were estimated using the provisions of the 2001 Title 24 Energy Efficiency Standards to define baseline conditions. The implicit assumption in choosing to define baseline conditions by code requirements is that buildings are usually built to just meet the standards and that therefore changes in the code can be given credit for any improvements in energy use beyond what people had to do under the previous code provisions.

4.2 REVIEW OF SAVINGS FROM TIME DEPENDENT VALUATION

Time dependent valuation (TDV) is a major change to the standards that will come into effect in 2005 and that will affect all building types covered by the standards. TDV energy replaces source energy for performance trade-off accounting in the standards. When source energy is used for trade-off accounting, the value of energy used does not differ across hours in the year. The assumption underlying the use of time dependent valuation is that energy saved at different hours of the year should be valued differently. For example, electricity used during peak periods costs more, and therefore reducing electricity use during those hours should be valued more highly. Time dependent valuation is an effort to bring more appropriate valuation of energy use into consideration when decisions are being made in designing and equipping newly constructed buildings.

While the theoretical advantages of TDV are perceived, estimates of the impacts that TDV will have on new construction practices and in saving energy and reducing peak demand were not addressed in the CASE Study Reports on the development and application of TDV or in the impact report prepared by Eley Associates.

For homebuilders, there is some evidence to suggest that they choose the efficiency of HVAC equipment in new houses to enable them to comply with the Title 24 standards. In their

Residential New Construction Study[2], RER observed a pattern in the choices of efficiency for HVAC equipment in new single-family houses "that could indicate that high efficiency cooling equipment is being used as a tool to achieve compliance for sites that would otherwise be non-compliant."[3]

With the introduction of TDV into the standards, the practice of using higher efficiency cooling equipment to obtain code compliance may become more prevalent. Under TDV, hours of peak electricity use carry more weight in the compliance calculation. New houses that are non-compliant can therefore come into compliance by using measures that reduce electricity use during peak hours (e.g., high efficiency cooling equipment, low-e glazing). This is especially true for hot climate areas where cooling requirements are high (e.g., CEC climate zones 11, 12, and 13).

Essentially, TDV changes the calculus by which builders can make trade-offs to comply with the code requirements. As in the past, this will require a trial-and-error process as builders evaluate the costs and benefits of different combinations of measures to comply with the code. At this point in time, there is a myriad of combinations, but which combinations are best is still being determined. Energy savings and demand reductions will depend on the particular combinations of measures that are finally chosen.

Although TDV may affect the choice of equipment that is installed in new houses and commercial buildings, estimating the extent to which energy will be saved and peak demand reduced is somewhat speculative given the information at hand. Heschong Mahone Group has developed some preliminary estimates of the savings impacts of TDV. To develop their savings estimates, HMG used the impact of EER requirements for small air conditioners as the proxy for assessing the overall impact of developing and applying the TDV methodology. With this approach, the assumption made is that TDV will encourage increased use of air conditioners with higher EERs (e.g., air conditioners with SEER of 13 and EER of 11 over air conditioners with SEER of 13 and EERs less than 11). Building on this basic assumption, HMG used detailed simulations of energy use for air conditioning in different climate zones in California to develop estimates of the savings that would result from increased sales of air conditioners with EERs of 11 or higher. The first year savings estimates that HMG developed from this analysis are shown in Table 4-3.

---

[2] Regional Economic Research, Inc., *Residential New Construction Study*¸ Prepared for Pacific Gas and Electric Company, September 2001.

[3] Ibid. p. 4-30.

Table 4-3. Estimates of First-Year Savings That Result because Time Dependent Valuation Encourages Improved EERs for Air Conditioners

Sector	Energy Savings (GWh)	Peak Reductions (MW)
Residential	6.70	27.20
Non-residential	4.30	18.70

4.3 REVIEW OF SAVINGS ESTIMATES FOR RESIDENTIAL SECTOR

This section presents a review of savings estimates for some residential sector code revisions that the C&S Program was instrumental in promoting. Savings are reviewed for the following code revisions:

- Hardwired lighting;
- Duct sealing;
- Window replacements; and
- Water heating for multifamily dwellings.

4.3.1 Savings Estimates for Hardwired Lighting in Residences

One of the code revisions adopted for 2005 is that high efficacy luminaries will be required for single family and multi-family dwellings, but with exceptions that allow automatic controls in some spaces.

The estimates for savings that will result from hardwired lighting that were prepared by Eley Associates for their impact report are reproduced in Table 4-4. A PG&E CASE report was developed for this proposed code revision, but no estimates were made of the aggregate savings likely to result from making this revision to the code.

Table 4-4. Estimates of Savings from 2005 Hardwired Lighting Requirement per Impact Report of Eley Associates

	Single Family	Multi-Family
Housing Units Affected	108,470	41,730
Aggregate Annual GWH Savings	55.5 GWh	9.1 GWh
Aggregate Annual Peak Demand Reduction	2.7 MW	0.27 MW

The estimated aggregate savings reported in Table 4-4 were derived by applying per-residence savings estimates from the impact report against projections of 108,468 new houses and 41,732 multi-family housing units to be built per year. In the impact report, Eley Associates estimated the per-residence savings from the proposed requirements for hard-wired lighting using two prototype buildings.

- For single-family houses, the CEC worked with the California Building Industries Association (CBIA) to develop lighting system takeoffs from blueprints of a representative 2,200 ft² single-family home.
- For multi-family buildings, a lighting design was developed for the prototype multi-family building used in the analysis of HVAC and building envelope measures.

These prototypes were used to determine the types of lighting systems and controls typically used in newly constructed single-family homes and multi-family dwelling units in California. For each prototype, the following information was determined:

- Rooms and spaces with hardwired lighting.
- Lighting fixtures and lamps per room/space.
- Mounting type for each fixture (surface, recessed, bath bar, wall, pendant).
- Lamp types (Incandescent, fluorescent).
- Control types that would comply with the 2005 Standards.

Using this information, electricity use and savings for lighting for single family and multi-family housing were estimated.

- The single-family prototype that was compliant with the 2001 standards was estimated to use 2,153 kWh for lighting per year, with a connected lighting load of 2,364 Watts. The single-family prototype house that was compliant with the 2005 standards was estimated to use 1,642 kWh for lighting per year, with a connected lighting load of 2,115 Watts. Thus, kWh savings would be 511 kWh per year. Coincident demand was estimated to be lower by 433 Watts.
- The multi-family prototype that was compliant with the 2001 standards was estimated to use 939 kWh for lighting per year, with a connected lighting load of 898 Watts. The single-family prototype house that was compliant with the 2005 standards was estimated to use 720 kWh for lighting per year, with a connected lighting load of 841 Watts. Thus, kWh savings would be 219 kWh per year. Coincident demand was estimated to be lower by 112 Watts.

The estimates of electricity use for lighting in residences are comparable to other estimates of residential lighting use, as summarized in Table 4-5.

Table 4-5. Comparison of Estimates of Residential Lighting UECs

Source	***Year***	***Lighting UEC (kWh/year)***
Manclark, et al.	1992	2,517
Hanford	1994	1,313
Hwang, et al.	1994	1,469
Heschong Mahone Group	1997	1,704
Tribwell and Lerman	1996	1,818
Navigant Consulting	2001	1,946

Because the impact report per-residence lighting use estimates are consistent with estimates from other studies, there is no reason to revise the aggregate savings estimates developed in the impact report.

4.3.2 Savings Estimates for Duct Improvements in Existing Homes

Under the 2005 standards, duct systems for houses in climate zones 2, 9, 10, 11, 12, 13, 14, 15, and 16 will have to be tested and sealed at the time that an air conditioner, heat pump, or furnace is replaced or installed in an existing building. Also, new or replacement duct systems in existing buildings will be required to have an insulation level that is the same as the prescriptive requirements for newly constructed buildings and to be tested and sealed.

Estimates of aggregate annual savings from duct sealing are reported in the impact report by Eley Associates and in a PG&E CASE report. These aggregate saving estimates are shown in Table 4-6.

Table 4-6. Estimates of Aggregate Savings from 2005 Duct Sealing Requirement

Savings Estimates	***PG&E CASE Report***	***Eley Associates Impact Report***
Houses Affected	255,000	50,000
Aggregate Annual GWH Savings	200 GWh	35.142 GWh
Aggregate Annual Peak Demand Reduction	160 MW	24.3 MW
Aggregate Annual Therm Savings	20,000,000 therms	2,719,430 therms

As can be seen in Table 4-6, there are significant differences between the aggregate savings estimates in the PG&E CASE report and in the impact report prepared by Eley Associates. Because of these differences, the estimates of the aggregate annual savings impact of the duct sealing requirement were reviewed by examining two factors: (1) savings per house and (2) number of houses affected. As the following discussion will show, review of these factors as reported in different studies indicates that the actual savings from duct sealing are open to further research.

Consider first the savings per house that will result from duct sealing. The savings per house can be inferred from the aggregate estimates in Table 4-5 by dividing the aggregate savings estimates by the number of houses. The inferred estimates of savings per house are shown in Table 4-7.

Table 4-7. Estimates of Savings per House from Duct Sealing as Inferred from PG&E CASE Study and Eley Impact Report

Savings Estimates	***PG&E CASE Study***	***Eley Associates Impact Report***
Inferred kWh Savings per house	784.3 kWh	702.8 kWh
Inferred kW reduction per house	0.627 kW	0.486 kW
Inferred therm saving per house	78.4 therms	54.4 therms

Compared to other estimates of savings from duct sealing, the savings per house for both electricity and natural gas shown in Table 4-7 are relatively high. For example, Table 4-8 reproduces the estimates of savings from duct repair that are reported in the Database on Energy Efficient Resources (DEER). (Note that the climate zones used for DEER are the zones that the CEC has defined for forecasting purposes, not for Title 24 compliance purposes.) As can be seen, even for houses built before 1978, the DEER estimates of savings per house in all zones are considerably lower than the estimates of savings per house reported in Table 4-7.

Table 4-8. DEER Estimates of Savings per House from Duct Repair

Type of Savings Estimate	***Vintage of House***	***CEC Forecasting Climate Zones***									
		1	***2,6***	***3,7***	***4***	***5***	***8,11***	***9,12, 16***	***10***	***13***	***15***
Energy kWh/house	Pre-1978	38.5	136.0	270.1	98.5	49.4	91.7	145.8	201.8	83.2	585.3
	1978-1992	23.4	128.9	258.4	68.7	28.7	67.3	118.8	148.0	59.3	451.6
	1992-1998	18.9	97.2	231.0	75.0	38.4	76.0	92.3	114.1	76.1	260.0
	Post-1998	14.0	83.6	203.2	67.8	33.3	74.3	100.1	148.5	79.0	312.4
Peak KW/house	Pre-1978	0.00	0.21	0.30	0.18	0.12	0.16	0.23	0.24	0.16	0.32
	1978-1992	0.00	0.15	0.21	0.14	0.10	0.15	0.20	0.21	0.14	0.28
	1992-1998	0.00	0.15	0.25	0.13	0.10	0.08	0.15	0.16	0.18	0.17
	Post-1998	0.00	0.13	0.22	0.12	0.10	0.11	0.16	0.20	0.17	0.18
Gas Therms per house	Pre-1978	42	40	32	29	36	21	26	30	16	16
	1978-1992	23	22	20	15	17	8	11	11	7	4
	1992-1998	12	15	12	8	10	4	3	4	3	1
	Post-1998	11	12	10	7	8	3	2	3	2	1

Weighted average savings estimates were calculated from the DEER estimates by using the distribution of the pre-1998 housing stock across climate zones and vintages for the weighting. The weighted average kWh savings was 114 kWh per year, while the weighted average gas savings was 22 therms per year. These weighted averages are lower than the estimates shown in Table 4-7.

Another set of estimates of savings per house for duct sealing was developed through econometric analysis in an assessment of measures installed through the Residential Contractors Program.[4] The kWh and therm savings estimates developed through that analysis are reported in Table 4-9. The kWh savings estimates are again lower than those reported in Table 4-7, although the therm savings estimates appear to be close.

[4] ADM Associates, *California Statewide Residential Contractor Program Energy and Market Impact Assessment Study: Final Report,* Prepared for Southern California Edison Company, October 2002.

Table 4-9. Econometric Estimates of Savings from Duct Sealing Performed by RCP Contractors by CEC Climate Zones (Ranges shown across weather stations within climate zones)

CEC Climate Zone	KWh per House	Therms per House
2	12 - 21	53 – 57
9	16 – 28	35 – 44
10	29 - 32	37 - 45
11	21 – 33	46 – 58
12	16 - 27	42 – 52
13	35 - 42	42 – 47
14	32 - 48	45 – 49
15	63	36 – 39
16	6 – 28	60 – 95

In a filing made in 2001 with the Low Income Governing Board for a Rapid Deployment Program, PG&E provided an estimate that the kWh savings from duct sealing would be 155 kWh.[5]

The other major factor in determining the aggregate savings from duct sealing in existing houses is the number of houses that will require duct sealing each year. Table 4-6 showed that there was a significant difference between the CASE report and the impact report in the assumption about how many houses would be affected by the duct sealing requirement. Further research on this factor is therefore appropriate.

There are several elements for which further data are required to estimate more precisely the number of houses that would be affected by the duct sealing requirement. One element pertains to the number of existing houses for which new furnaces, central air conditioners, or heat pumps are installed each year. A second element pertains to the percentage of these houses that will require duct sealing. A third element pertains to how enforcement of the code provisions will affect the number of houses that actually proceed to receive the duct sealing.

In the PG&E CASE report regarding duct sealing requirements, data provided by Carrier Corporation were referenced as indicating that there are somewhat more than 300,000 furnaces, air conditioners, or heat pumps installed in existing homes in California each year. Other data regarding replacement of such equipment are provided by the American Housing Survey (AHS). In particular, the national American Housing Survey for 2001 contains information for a sample

[5] In addition, the joint utilities removed duct sealing as a rebatable measure in the program filing that they made to the CPUC at the end of 2001 for the Single-Family Rebate Program in 2002. The reason given for not providing rebates for duct sealing was that the measure was not cost effective. Also, duct sealing was not included as an approved measure for the low-income programs that the utilities administer.

of 4,648 existing housing units located in several SMSAs across California. The data for these units can be weighted to provide estimates of housing characteristics for the entire state.

Of interest to the analysis here, the 2001 AHS provides data on replacements and/or additions made to owner-occupied single family houses during the two years prior to the AHS interview. Among other items, respondents in owner-occupied single family units were asked if they added or replaced air conditioning or built-in heating equipment. Table 4-10 shows the statewide estimates of equipment replacement derived from the AHS data.

Table 4-10. Replacements of Central Air Conditioning or Built-In Heating Equipment over a Two-Year Period for Owner-Occupied Single Family Houses in California (Based on data from 2001 American Housing Survey)

Action	***Number***	***Percent of All***
All owner-occupied single family houses	4,346,735	100%
Replaced only central air conditioning equipment	94,985	2.2%
Replaced only built-in heating equipment	143,475	3.3%
Replaced both types of equipment	95,960	2.2%
Total replacing heating or cooling equipment	334,420	7.7%

Thus, heating or cooling equipment is replaced in about 7.7% of owner-occupied single family houses over a two-year period. Assuming these replacements are equally spread over the two years, about 3.85% of owner-occupied single family houses have heating or cooling equipment replaced in a single year.

The requirement for duct sealing for existing houses applies only to houses in climate zones 2 and 9 through 16. Based on the data provided in Eley Associates' impact report, there are 1,429,523 houses in these climate zones. When the estimate of 3.85% of houses that have heating or cooling equipment replaced in a year is applied to this number for the housing stock, the resulting estimate is of about 55,040 houses replacing equipment in the designated climate zones. The estimate made in the impact report that 50,000 houses per year would be affected by the duct sealing requirement is therefore in accord with this number.

A question also arises that relates to the percentage of these houses that are also candidates for duct sealing. In the PG&E CASE report on duct sealing, data collected on 1,000 houses by Aeroseal Inc. in Sacramento for SMUD were referenced as indicating that approximately 85% of the system installations inspected would require duct sealing. (These data underlie the estimate of about 250,000 existing homes requiring duct sealing each year that is reported in Table 4-6 for the PG&E CASE report.)

There are other data that suggest that not all of the households for which ducts are tested will voluntarily go ahead with duct sealing.

- Over the three-year period from 2000 through 2002, about 4,400 houses in SMUD's service territory received diagnostic testing of their duct systems from Aeroseal contractors participating in SMUD's duct sealing program. About 40% (1,785) of the houses that received duct testing then received duct sealing.

- During the PY2000 RCP, about 2,535 PG&E customers received duct tests from RCP contractors. About 65% (1,643) of these customers then received duct sealing services after the duct testing. For SCE, about 3,465 customers received duct tests from RCP contractors. About 58.5% (2,026) received duct sealing services after the duct testing.[6]

Taken together, these data represent 10,400 houses that received duct testing, of which about 52% (5,455) also received duct sealing.

These estimates indicate that, if given a voluntary choice, not all households whose ducts may require sealing will actually go ahead to have them sealed. What is unknown here is the degree to which the code requirement for duct sealing for existing houses will be enforced. That is, if the code requirement is fully enforced, then all of the houses requiring duct sealing when they change furnaces or air conditioning would be expected to have such sealing performed. However, if the enforcement is less than complete, then there will be houses requiring duct sealing that will choose not to have the service performed. Because it is not clear at this point in time what the provisions will be for enforcing the duct sealing requirement for existing houses, estimates of the number of existing houses per year that will receive duct sealing because of the requirement must be speculative.

This review suggests that the aggregate savings estimates developed in the CASE report and in the impact report are significantly higher than when savings are computed using the other evidence just presented. If the DEER weighted average savings estimates are applied to the 50,000 houses that are assumed to be affected in the impact report, the expected aggregate savings are reduced from 35.1 GWh to 5.7 GWh, peak demand reductions go from 24.3 MW to 8.5 MW, and the therm savings are reduced from 2,719,430 therms to 1,105,000 therms.

4.3.3 Savings Estimates for Window Replacements in Existing Homes

Under the proposed Standards, replacement fenestration will be required to meet the prescriptive package requirements. Estimates of aggregate annual savings from window replacements are reported in the impact report by Eley Associates and in a PG&E CASE report. These aggregate saving estimates are shown in Table 4-11.

Table 4-11. Estimates of Savings from 2005 Window Replacement Requirement

Savings Estimates	***PG&E CASE Study***	***Eley Associates Impact Report***
Houses Affected	100,000	25,000
Aggregate Annual GWH Savings	10.125 GWh	6.34 GWh
Aggregate Annual Peak Demand Reduction	4.75 MW	2.4 MW
Aggregate Annual Therm Savings	250,000 therms	295,646 therms

[6] ADM Associates, *op. cit.*

The PG&E CASE report developed estimates of statewide savings for replacing windows in existing houses. For that study, the market size for replacement windows in California was estimated to be about 1.5 million windows per year. On the assumption that 15 windows were replaced per house, it was projected that 100,000 homes a year have windows replaced. Statewide energy savings for one year's worth of replacement windows, reduced to account for energy efficient window replacements that would have occurred without this proposed change, were estimated to be 10.125 GWh and 250,000 therms, with demand reduction of 4.75 MW.

In the impact report prepared by Eley Associates, it was assumed that 25,000 houses per year will be affected by the code changes for fenestration replacement. Using the methodology described in the CASE report, aggregate first-year impacts from fenestration replacement were estimated in the impact report to be savings of 6.34 GWh and 295,646 therms and peak demand reduction of 2.4 MW.

To review these estimates of the aggregate annual savings impact of the fenestration replacement requirement, two factors are examined: (1) savings per house from window replacement and (2) number of houses affected. These factors reported in different studies were reviewed to determine whether estimation of savings from window replacements is open to further research.

Savings per house from window replacement were estimated for the impact report using the results from Micropas simulations. Based on an averaging of results from Micropas simulations, it was estimated that window replacement saves 10% of heating energy and 20% of the cooling energy and reduces cooling demand by 10%. Savings per house vary across climate zones, as shown in Table 4-12.

Table 4-12. Estimated Savings per House from Window Replacement as Reported in Eley Associates' Impact Report

Climate Zone	***KWh Savings per House***	***KW Reduction per house***	***Therm Savings per House***
1	7	0.0	19
2	257	0.2	21
3	68	0.0	11
4	186	0.1	13
5	98	0.1	14
6	146	0.1	6
7	159	0.1	5
8	241	0.1	7
9	350	0.2	8
10	428	0.3	11
11	438	0.3	19
12	347	0.2	17
13	506	0.3	15
14	525	0.3	20
15	1,090	0.6	6
16	155	0.1	46

A different set of estimates of savings from installing high performance windows were developed through econometric analysis during an assessment of the 2000 Residential Contractors Program.[7] The kWh and therm savings estimates developed through that analysis are reported in Table 4-13. The kWh savings estimates are lower than those reported in Table 4-11, although the therm savings estimates appear to be close to those reported in Eley Associates' impact report.

Table 4-13. Econometric Estimates of Savings from High Performance Windows Installed by RCP Contractors by CEC Climate Zones (Ranges shown across weather stations within climate zones)

CEC Climate Zone	***KWh per house***	***Therms per house***
1	204	77
2	287 – 585	58 – 63
3	178 – 227	36 – 60
4	231 – 589	32 – 68
6	118 – 140	25 – 50
9	135 – 160	32 – 65
10	141 – 163	28 – 54
11	556 – 826	35 – 68
12	363 –725	30 – 48
13	170 – 1,048	15 – 57
14	167 – 177	38 – 73
15	146 – 155	-13 - -22
16	210 – 311	119 – 283

Figure 4-1 compares the estimates for kWh savings from Table 4-12 to those from Table 4-13 for different climate zones. This comparison shows kWh savings from the impact report being higher than the econometric estimates for some climate zones and lower for other zones.

The number of existing houses that will be affected by the revised fenestration requirements each year is also open to further research. There are two elements to consider. One element pertains to the number of existing houses for which windows are replaced each year. The second element pertains to the percentage of these houses that will be required to meet the new standards.

[7] ADM Associates, *op. cit.*

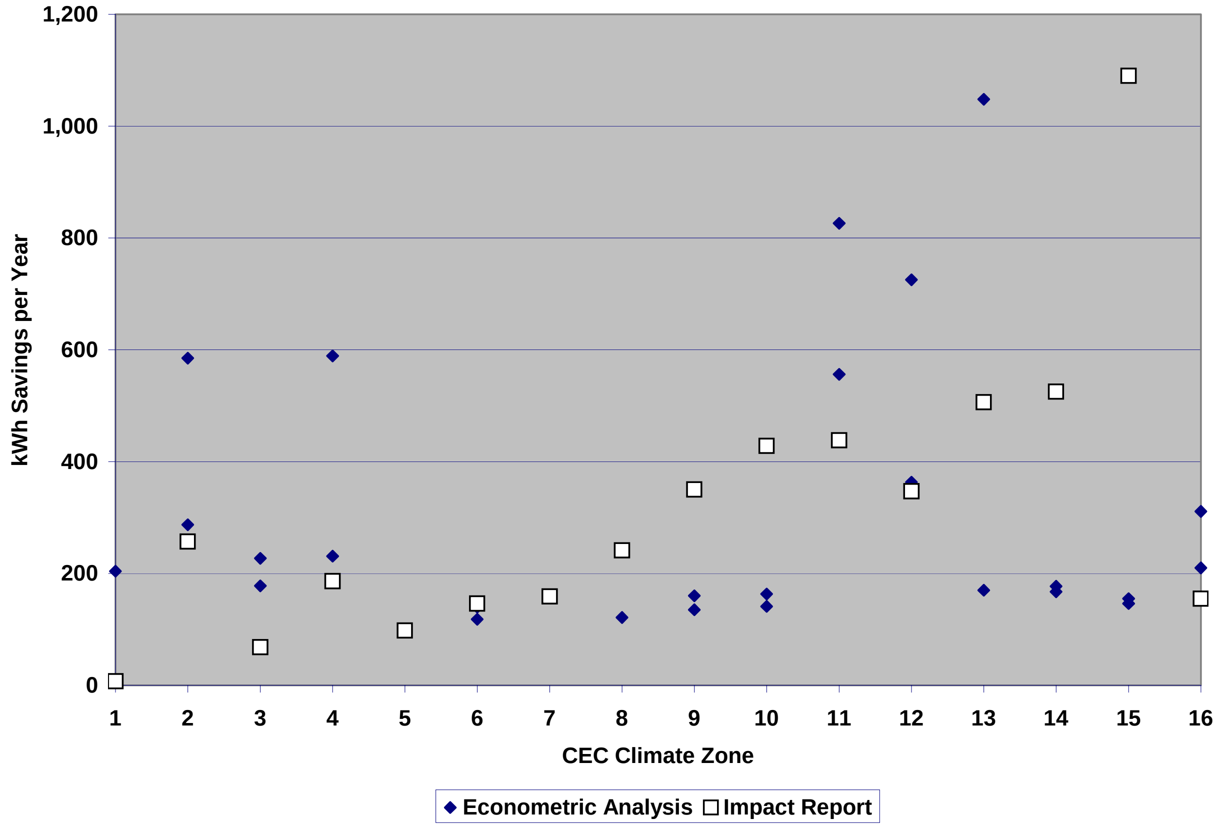

Figure 4-1. Comparison of kWh Savings from Window Replacement: Eley Associates Impact Report vs. RCP Econometric Estimates

Data regarding replacement of windows in owner-occupied single family houses are provided by the American Housing Survey. The 2001 AHS provides data on replacements and/or additions made to owner-occupied single family housing units during the two years prior to the AHS interview. Among other items, respondents in owner-occupied single family units were asked if they had added or replaced windows. Table 4-14 shows the statewide estimates of window replacements derived from the AHS data.

Table 4-14. Owner-Occupied Single Family Houses in California for Which Windows Were Replaced over a Two-Year Period (Based on data from 2001 American Housing Survey)

Action	***Number***	***Percent of All***
All owner-occupied single family houses	4,346,735	100%
Replaced windows	644,945	14.8%

Thus, windows were replaced in about 14.8% of owner-occupied single family houses over a two-year period. Assuming these replacements are equally spread over the two years, about 7.4% of owner-occupied single family houses have one or more windows replaced in a single year. Based on the number of owner-occupied single family houses reported in Table 4-9, this implies window replacement in about 322,470 of these houses each year.

Data were not collected in the AHS on window replacement in renter-occupied single family houses. AHS data indicate that there are about 1,327,980 renter-occupied single family houses in California. If the rate of window replacement for these houses is similar to that for owner-occupied single family houses, then windows are replaced in about 196,540 renter-occupied single family houses over a two-year period. For a single year, this would imply windows being replaced in about 98,270 renter-occupied single family houses.

Taken together, these estimates suggest that windows are replaced in about 420,740 existing single-family houses in a year. However, as with the requirement for duct sealing, the degree to which the code requirement regarding window replacements for existing houses will be enforced is not known. That is, if the code requirement is fully enforced, then all of the houses replacing windows would be expected to install windows that meet the requirement. If the enforcement is less than complete, then there will be houses that will choose not to meet the requirement.

Enforcing the code provision for window replacements may be problematic. There is evidence that few households now obtain permits when they replace windows and thus are not exposed directly to the enforcement of the code requirement. As an example to illustrate this point, data from the City of San Jose regarding permits issued during 2000 were inspected. At the start of 2000, there were approximately 186,465 single-family houses in San Jose. Applying the 7.4% estimate of houses replacing windows each year that was derived from the AHS data, then there were about 13,800 houses in San Jose that would have replaced windows during 2000. In fact, however, there were only 270 permits issued in San Jose during 2000 in which replacement of windows was involved. Only about 2% of the estimated houses replacing windows applied for permits.

This points up that the provisions used to enforce the requirement for obtaining a permit for window replacement in existing houses will affect the estimation of the number of existing houses per year that will be affected by the code's requirements on window replacements. Estimates of the aggregate savings from window replacements resulting from the code requirement will depend on how many homeowners are expected to abide by permitting requirements. In the absence of other data to the contrary, the estimates of savings developed for the *Impact Report* can be taken as the more conservative estimate of expected annual savings from the code's requirements on window replacements.

4.3.4 Savings Estimates for Multifamily Water Heating Code Revisions

A code revision was adopted for 2005 that establishes a central system as the standard design for multifamily buildings that install central system water heating. Under this code revision, the water heating budget for systems serving multiple dwelling units will be based on a central recirculating water heating system with gas water heaters and timer controls. This 2005 revision replaces the earlier code provision whereby the baseline water heating budget for all building types (multifamily as well as single family) was determined by assuming one storage water heater per dwelling unit. Because of the large amount of standby loss associated with each individual water heater, a substantial energy credit could be obtained under the earlier code provision by installing a central water heating systems. This credit could be traded-off against envelope and HVAC equipment options, resulting in a below-standard building design. The 2005 code revision for multifamily water heating effectively removes the opportunity for making this trade-off. Savings therefore result because worse-than-prescriptive envelope and HVAC equipment options are no longer possible.

In their impact analysis for the 2005 energy standards revisions, Eley Associates estimated the energy savings impact of implementing the code revision for multifamily water heating through the modeling of a multifamily prototype building.[8] Energy savings were determined by comparing the results of Micropas simulations of the prototype building under minimal compliance with the 2001 and 20005 standards. Separate simulations were made for the 16 climate zones in California. Based on this analysis, Eley Associates estimated that the first-year savings that would result from the code revision for multifamily water heating would be just over 1.5 million therms. The data for calculating this estimate are shown in Table 4-15.

Table 4-15. Estimates of Therm Savings from Multifamily Water Heating Code Revision

Climate Zone	***Therms saved per New MF Dwelling Unit***	***Number of New MF Dwelling Units***	***Therms Saved per Year***
1	30.85	89	2,746
2	31.26	1,344	42,013
3	31.26	3,758	117,475
4	31.44	4,596	144,498
5	31.27	412	12,883
6	41.86	7,978	333,959
7	42.10	3,967	167,011
8	42.19	1,890	79,739
9	42.35	2,575	109,051
10	42.40	4,763	201,951
11	31.67	1,220	38,637
12	31.47	5,154	162,196
13	32.16	686	22,062
14	31.89	629	20,059
15	34.66	1,793	62,145
16	30.56	880	26,893
Total		41,734	1,543,320

[8] The multifamily prototype was assumed to be a 9,016 ft^2, two-story slab-on-grade apartment building with 8 dwelling units.

Nearly 60% of the expected savings come in climate zones 6 through 10. In these zones, 40% of the new multifamily dwelling units were assumed by Eley and Associates to receive hot water though a central water heating system. In the other climate zones, 15% of the new units were assumed to receive hot water from a central system. These estimates of the percentages of that receive hot water through a central system are consistent with estimates developed through the *Statewide Multifamily Common Area and Building Owners Survey*.[9]

4.4 REVIEW OF SAVINGS ESTIMATES FOR NONRESIDENTIAL SECTOR

This section reviews estimates of savings for nonresidential sector code revisions that the C&S Program was instrumental in promoting. Savings are reviewed for the following code revisions:

- Lighting controls under skylights;
- Improvements to existing light commercial buildings (i.e., for duct improvements)
- Cool roofs;
- High performance relocatable classrooms;
- Bi-level lighting control credits;
- Ducts and attics in light commercial buildings; and
- Cooling tower applications.

4.4.1 Savings Estimates for Lighting Controls under Skylights

The revised standards that will take effect in 2005 will include changes with respect to controls for lighting under skylights. Automatic controls will be required to control fixtures in the daylit area. There will also be a requirement for skylights to provide 50% daylighting for low-rise nonresidential buildings with over 25,000 square feet in floor area, with ceiling heights greater than 15 feet, and with a lighting power density equal to or greater than 0.5 watts per square foot. Electric lighting in daylighted areas is to be controlled with multi-level automatic daylighting controls. This requirement will apply primarily to warehouses and to big-box retail stores. Buildings in climate zones 1 and 16 do not have to satisfy this requirement, nor do auditoriums, movie theaters, and museums.

Direct estimates of the aggregate savings from this revision to the standards are not provided either in the PG&E CASE study report or in the impact report prepared by Eley Associates. The impact report describes the methodology used to analyze this revision, but does not report the estimated savings separately from other lighting measures. The savings from lighting controls under skylights are included within the overall aggregate lighting savings for nonresidential new construction.

[9] ADM Associates, *Statewide Multifamily Common Area and Building Owners Survey: Final Report, Volume 1, for Apartment Complexes*, June 2000.

The aggregate annual savings impact of the requirement for lighting controls under skylights will depend on two factors: (1) savings per square foot for buildings where the controls are installed and (2) the square footage of the buildings where the controls are installed. Available information on these factors was reviewed to determine how well the aggregate savings from this measure can be estimated using currently available data.

A detailed analysis of the savings that could be realized from installing lighting controls under skylights was developed by the Heschong Mahone Group (HMG) in a PG&E CASE report.[10] The savings from such controls effectively result by reducing the number of hours that the lighting is on. The extent of the reduction is captured through the use of power adjustment factors, which effectively reduce baseline assumptions regarding hours of lighting when applied.

For their analysis to develop revised power adjustment factors, HMG specified two prototypical buildings.

- A prototypical retail store was assumed to use lighting for 5,293 full load hours per year. Although the overall lighting power density was assumed to be 2.0 Watts per square foot, 20% of the lighting was assumed to be display lighting that would be unaffected by the amount of daylight available. The lighting power density for the lighting affected by daylighting would therefore be 1.6 Watts per square foot. On these assumptions, lighting consumption would be 8.5 kWh per square foot of store area per year.
- The prototypical warehouse was assumed to use lighting for 4,428 full load hours per year. The lighting power density was assumed to be 0.7 Watts per square foot. On these assumptions, lighting consumption would be 3.1 kWh per square foot per year.
- For both prototypes, it was assumed that 10% of general lighting was not controlled (e.g., emergency lighting or other lighting outside the controlled zones). Under this assumption, the controlled lighting power densities were 1.44 Watts per square foot for the retail prototype and 0.63 Watts per square foot for the warehouse prototype.

The assumptions for full load hours per year that were assumed in the CASE Study report are higher than have been reported in other sources. For example, in Xenergy's[11] report on the potential for energy efficiency in the commercial sector, estimates were provided of equivalent full load hours of indoor lighting for retail stores and warehouse in the service territories of PG&E, SCE and SDG&E. These hours of use, as shown in Table 4-16, are lower than were assumed in the CASE study report.

[10] Heschong Mahone Group, *Code Change Proposal for Updates to Title 24 Treatment of Skylights,* Codes and Standards Enhancement Study, Prepared for Pacific Gas and Electric Company, May 2002.

[11] Xenergy, Inc, *California Statewide Commercial Sector Energy Efficiency Potential Study: Final Report,* Prepared for Pacific Gas and Electric Company, July 2002.

Table 4-16. Estimates of Equivalent Full Load Hours of Indoor Lighting for Retail and Warehouse Facilities[12]

	PG&E	SCE	SDG&E
Retail	3,068	3,113	3,332
Warehouse	1,857	3,212	3,354

Other estimates of the installed lighting power densities for warehouses and retail facilities are available from the commercial sector energy use surveys that PG&E and SCE conducted in the mid 1990's. The lighting power densities estimated from those survey data are reported in Table 4-17; they are comparable to the estimates of lighting power densities made in the CASE Study report.

Table 4-17. Estimates of Lighting Power Densities for Retail and Warehouse Facilities[13]

Type of Facility	PG&E	SCE
Retail	1.46	1.49
Warehouse	0.65	
Non-refrigerated		0.59
Refrigerated		0.66

Using these and other data, approximate estimates of the aggregate savings from daylighting controls under skylights can be developed. Estimates for the aggregate savings from photocontrols are shown in Table 4-18 for the retail sector and in Table 4-19 for the warehouse sector. These savings are reflect (1) the mandatory requirement for automatic daylighting control devices that can be provided through timeclocks and (2) the additional control from use of photocontrols. (That is, the savings from use of photocontrols are added on to the savings from using multi-level astronomical timeclocks. The total savings are split equally between the two types of controls.)

Table 4-18. Estimated Annual Savings from Lighting Controls under Skylights: Retail

Utility Service Territory	Annual Hours of Use	Controlled LPD	Power Adjustment Factor	New Construction per Year (1,000 SF)	Percent of Square Footage above 25k SF per Buildings	Total Square Footage for Buildings above 25k (1,000 SF)	Savings per Year (GWh)
PG&E	3,068	1.44	0.412	7,979	18.2%	1,452	2.64
SCE	3,113	1.44	0.412	9,842	18.2%	1,791	3.31
SoCalGas	3,113	1.44	0.412	444	18.2%	81	0.15
SDG&E	3,332	1.44	0.412	2,258	18.2%	411	0.81
Non IOU	3,157	1.44	0.412	3,712	18.2%	675	1.26
Total				24,234		4,410	8.18

[12] Ibid.

[13] Ibid,

Table 4-19. Estimated Annual Savings from Lighting Controls under Skylights: Warehouse

Utility Service Territory	Annual Hours of Use	Controlled LPD	Power Adjustment Factor	New Construction per Year (1,000 SF)	Percent of Square Footage above 25k SF per Buildings	Total Square Footage for Buildings above 25k (1,000 SF)	Savings per Year (GWh)
PG&E	1,857	0.63	0.574	9,456	44.3%	4,185	2.81
SCE	3,212	0.63	0.574	20,341	44.3%	9,003	10.46
SoCalGas	3,212	0.63	0.574	786	44.3%	348	0.40
SDG&E	3,354	0.63	0.574	2,248	44.3%	995	1.21
Non IOU	2,909	0.63	0.574	5,164	44.3%	2,286	2.40
Total				37,994		16,816	17.28

The data for the calculations in Tables 4-18 and 4-19 are from the following sources.

- The data for hours of use are from Table 4-16.
- The data for controlled lighting power densities are from the CASE Study report.
- The power adjustment factors are calculated from the PAF formula in the CASE Study report, assuming an effective aperture of 1.5%.
- The data for annual square feet of new construction are the averages of new construction in 2001 and 2002 as reported in the *NRNC Market Characterization and Program Activities Tracking Reports for PY2001 and PY2002.* The data for storage in these reports has been used as warehouse space.
- The percentages of total square footage that is in facilities with more than 25,000 square feet were derived from data on the size distributions of retail and warehouse facilities as reported in PG&E's *Commercial Building Survey Report: 1999.*

The calculations in Tables 4-18 and 4-19 show estimated annual savings from lighting controls under skylights of 8.18 GWh for retail facilities and 17.28 GWh for warehouse facilities. The largest savings are attributable to warehouse facilities in SCE's service territory.

4.4.2 Savings Estimates for Improvements to Existing Light Commercial Buildings

Under this code revision, the 2005 Standards will require that ducts be sealed when air handlers, cooling coils or furnace heat exchangers are replaced in existing buildings where greater than 30% of the duct surface area is outside of conditioned space. The Standards will also require that ducts be sealed and duct insulation be increased to R-8 when ducts are replaced or new ducts are installed. For the 2001 standards 36% total leakage and R-4.2 duct insulation is assumed. For the 2005 standards, 15% total leakage and R-8 duct insulation is assumed.

The savings related to this requirement that were reported in a PG&E CASE report and in the impact report are shown in Table 4-20.

Table 4-20. Estimates of Savings from Duct Sealing Requirement for Existing Nonresidential Buildings

Savings Estimates	***PG&E CASE Report***	***Eley Associates Impact Report***
What is affected	74,000 HVAC units replaced	37.015 million sf
Aggregate Annual GWH Savings	46 GWh	9.73 GWH
Aggregate Annual Peak Demand Reduction	35 MW	7.36 MW
Aggregate Annual Therm Savings	500,000 therms	1,035,000 therms

Of the 9.73 GWh in total annual savings estimated in the impact study to come from duct sealing in existing nonresidential buildings, 8.45 GWh of these savings were attributed to cooling savings and 1.28 GWh were attributed to heating savings.

As can be seen in Table 4-20, there are significant differences between the aggregate savings estimates in the PG&E CASE report and in the impact report prepared by Eley Associates. Accordingly, these estimates of the aggregate annual savings impact of the duct sealing requirement for existing nonresidential buildings were reviewed by examining two factors: (1) unit savings and (2) number of units affected. As the following discussion will show, review of these factors as reported in different studies indicates that the actual savings from duct sealing in existing commercial buildings are open to further research.

The procedure for estimating unit savings was similar in the CASE report and in the impact report. In both cases, expected savings from this code revision were estimated by applying ASHRAE 152 calculations, as described in Appendix NG of the nonresidential ACM.

The significant differences between the CASE study report and the impact report in the aggregate estimates of savings appear then to be attributable to different assumptions about the amount of HVAC equipment that will be affected each year by the duct sealing requirement.

- For the CASE Study report, it was assumed that 140,000 air conditioners, furnaces, and heat pumps are replaced in existing commercial buildings each year. Results from research performed by Lawrence Berkeley National Laboratory were used to estimate that 60% to 65% (an average of 62.5%) of the duct systems in the existing buildings where this equipment is installed would meet the eligibility criteria for application of the proposed changes. Results from research conducted for Southern California Edison indicated that more than 85% of the duct systems tested in light commercial buildings merited sealing. On these assumptions, 74,000 HVAC units per year would merit and receive duct sealing (i.e., 0.625*0.85*140,000).
- For the impact report, CEC data were used to characterize the distribution of square footage of existing commercial buildings across building types. A sample of buildings drawn from the nonresidential new construction (NRNC) database was used to estimate, by building type, the amount of square footage that would be subject to the duct sealing requirement. The

assumptions that were used in the CASE study report about the percentage of buildings that actually met the eligibility requirement (62.5%) and the percentage that merited duct sealing (85%) were also used in the impact study. It was also assumed that the service life of an HVAC unit is 20 years, implying that 5% of existing units are replaced each year. Through these assumptions, it was estimated that a total of 37.015 million square feet of existing commercial buildings would be affected by the duct sealing requirement each year. However, with the energy savings estimates being scalable against the units affected, the fact that the impact report savings are about 21% of the CASE Study report savings implies that the number of units considered affected for the impact report is about 15,650.

The difference between the two calculations arises mainly because of the first step in the impact report analysis where the data from the NRNC database are used to estimate the amount of square footage that would be subject to the duct sealing requirement. If this step were not applied, the total square footage subject to the requirement would be estimated as about 151.4 million square feet (i.e., 5.7 billion sf x .05 x .625 x .85). However, with the first step applied, the affected square footage falls to 37.015 million square feet, which is about 24.4% of the 151.4 million square feet.

In substantive terms, it is assumed in the CASE report that all of the 140,000 HVAC units installed in existing commercial buildings each year are installed in spaces covered by the duct sealing requirement. In the impact report, however, it is assumed that not all commercial space is covered by the duct sealing requirement. That is, some of the HVAC units are installed in spaces that are not covered by the duct sealing requirement. Because the analysis in the impact report has applied a finer filter, the estimates developed there are probably more representative of the savings to be expected.

As noted in the CASE report, a “key issue with respect to enforcement of this change in the Standards is the potentially significant fraction of HVAC equipment that is installed without building permits”. However, neither the CASE report nor the impact report provides an analysis of the possible quantitative impact arising from this issue.

4.4.3 Savings Estimates for Cool Roofs

The proposed code revision for cool roofs for the 2005 Standards requires that when a low-slope roof on a nonresidential building is replaced, it be replaced with a cool roof with an initial reflectance of at least 70% and an emittance greater than 75%.

The aggregate savings related to this requirement that were reported for the cool roof measure in the CASE report[14] and in the impact report are shown in Table 4-21.

[14] PG&E, *Inclusion of Cool Roofs in Nonresidential Title 24 Prescriptive Requirements*, Revised Report, August 2002.

Table 4-21. Estimates of Savings from Cool Roofs Requirement

Savings Estimates	***PG&E CASE Report***	***Eley Associates Impact Report***
What Affected	Not reported	44.751 million sf
Aggregate Annual GWH Savings	43.0 GWh	14.6 GWh
Aggregate Annual Peak Demand Reduction	26.7 MW	9.5 MW
Aggregate Annual Therm Savings	-577,000 therms	- 203,465 therms

In the CASE report, the analysis of aggregate savings focused primarily on the new construction market. Data from the NRNC database were used to determine the savings from installing cool roofs on newly constructed commercial buildings. Because data were not available regarding the replacement of roofs on existing buildings, the aggregate savings for existing buildings were estimated by assuming that the savings were in the same proportion as the ratio of replacement roofing sales to new roof sales (i.e., about 2.9 to 1).

The aggregate savings estimates reported in the impact report were developed using data from the analysis developed for the CASE report. Using the data developed in the CASE report, the analysis presented in the impact report determined that for each 1,000 square feet of roof area that is a cool roof as opposed to a standard roof, use of electric energy would be reduced by a statewide weighted average of 327 kWh and demand would be reduced by 0.21 Watts. Gas use would be increased by an average of 4.5 therms. These figures, which apply only for buildings that are air conditioned, were developed by estimating savings for each of 16 climate zones and then developing the weighted statewide average using the percentages of total commercial floor space in the climate zones for the weighting.

The CASE report presents estimates of kWh savings and demand reductions as estimated from other studies of cool roofs as evidence that the estimates developed in the CASE study are within the range established by other studies. Since the preparation of the CASE Study, additional data on demand reductions have become available through the evaluation that Nexant has performed of the CEC's AB29X and SB5X Peak Load Reduction Program Elements.[15] Nexant reported that "as of mid-December 2002, the AB970 and SB5X program elements combined, had enrolled over 2,150 customers and achieved 11.0 MW of verified savings through the installation of over 33 million square feet of cool roof material, all at a cost of less than $80/kW-year". This implies a demand reduction of 0.33 kW per 1,000 square feet of roof. Thus, the estimate of 0.21 kW per 1,000 square feet that was developed in the CASE report and used in the impact report analysis appears conservative.

On the other hand, the results of the Cool Roof element of the CEC's program in terms of the amount of square footage where cool roofs were installed raises a question about achieving installation of cool roof material on 44.751 million square feet of roofs each year. Over a two-

[15] Nexant, Inc., *Evaluation of the California Energy Commission's AB29X and SB5X Peak Load Reduction Program Elements: Final 2002 Report*, May 2003.

year period, contractors working under the CEC program installed a total of 33 million square feet of material (i.e., an average of about 16.5 million square feet per year). This average is just over a third of the annual amount of material that was projected in the impact report to be installed, suggesting that some effort will be required to develop an infrastructure that can install the expected quantities of cool roof materials.

4.4.4 Savings Estimates for High Performance Relocatable Classrooms

The 2005 Standards will add requirements for relocatable classrooms that will apply statewide.

In the impact report prepared by Eley Associates, unit energy savings estimates from the PG&E CASE report on relocatable classrooms[16] were used to estimate statewide savings. In the CASE report, savings expected from the proposed code changes were estimated for relocatable classrooms located in five climate zones. Averaged across the climate zones, the estimated savings from the proposed changes in the standard were 1,043 kWh per year for each relocatable classroom. Based on an estimate of 3,000 relocatable classrooms being constructed each year, the estimated statewide impact is 3.1 GWh. There are no gas savings associated with relocatable classrooms because all are assumed to be conditioned with an electric heat pump.

The estimated statewide average savings of 1,043 kWh per year per classroom is based on a simple averaging of savings across the five climate zones used in the analysis. However, because the populations differ across the climate zones, it may be more appropriate to use a weighted average savings estimate. Data on the number of housing units per climate zone were taken from Table 49 of the impact report and used as weights to derive a weighted average statewide estimate of savings per classroom. This estimate was 970 kWh per year per classroom, implying aggregate savings of 2.9 GWh per year.

4.4.5 Savings Estimates for Bi-Level Lighting Control Credits

Under this codes and standards enhancement initiative, control credits were developed to encourage the use of occupancy sensors, timers and specialized switching strategies in conjunction with bi-level lighting controls in intermittently occupied areas in new buildings. Control credits were developed for the following types of areas:

- Corridors in hotels and high-rise residential;
- Small office areas;
- Library stack areas; and
- Warehouse stack areas.

The credits allowed for installing specified controls in these areas can be applied to the "actual lighting power" calculation so that fewer installed watts are counted toward the overall allowed

[16] PG&E, *Code Change Proposal for High Performance Relocatable Classrooms,* Codes and Standards Enhancement Report, June 2002..

lighting power. In practice, the watts associated with the control credits can be applied elsewhere in the building design or used as a trade-off against other energy features.

Were the control credits of the same magnitude as the expected savings from the control measures, their effect would be expected to be energy neutral. However, the credits, which are incorporated into the code through Power Adjustment Factors, do not take all of the energy savings that the control measures afford. Hence, to the extent that the control credits encourage the adoption of the control measures they result in savings over and above the savings that are reflected in the credits.

Estimates of the savings attributable to the bi-level lighting control credits were developed using data from the Nonresidential New Construction database. This database contains information on the areas and lighting power densities for identifiable spaces within newly constructed buildings and on the schedule for lighting use within the building.

The database also contains information identifying which of the spaces have lighting controls installed. This information was used as a means to determine the proportion of a given type of space that would be likely to also be considered for installation of bi-level lighting controls.

Using this information, estimates were developed of the expected annual lighting use for those spaces where bi-level lighting controls would likely be installed. These estimates were developed on a building-by-building basis for the sample of buildings in the NRNC database, and NRNC case weights were applied to these results to expand them to represent the population of newly constructed buildings in a given year. In effect, this calculation gave the expected annual lighting use for a given type of space under conditions where lighting was not controlled.

Estimates had been developed in the CASE study report for bi-level lighting control credits that showed the potential savings per watt controlled when bi-level lighting controls are installed in different types of spaces.[17] That report also gave the power adjustment factors that determined the credits that would be allowed if the controls were applied to a space. The power adjustment factors can be applied to determine the amount of savings that could be taken as control credits. The estimates from the CASE report are shown in Table 4-22. For example, installation of the lighting controls associated with the bi-level lighting control credits would expected to reduce expected annual lighting use by 32 percent. However, the power adjustment factor implies that 20 percent of expected annual lighting use would be used for the control credits. In effect, the control credits initiative should provide 12 percent savings for office spaces where the control measures are installed.

[17] PG&E, *Bi-Level Lighting Control Credits*, CASE Initiative prepared by Heschong Mahone Group, June 2002

Table 4-22. Estimates of Savings Percentages for Bi-Level Lighting Controls from CASE Report on Bi-Level Lighting Control Credits

Type of Space	Potential Savings per Watt Controlled	Recommended Power Adjustment Factor
Office	0.32	0.20
Corridors	0.50	0.25
Library stacks	0.50	0.25
Warehouse spaces	0.30	0.15

The savings percentages implied by the estimates in Table 4-22 were applied to the estimates of expected annual lighting use for the different types of spaces to determine the total savings attributable to the control measures, the amount of those savings that were applied to developing the Title 24 control credits, and the amount of savings attributable to the CASE initiative. The resulting estimates are reported in Table 4-23. Overall, annual kWh savings attributable to the bi-level lighting control credits initiative total about 12.1 GWh. Because the savings occur mostly during hours when the spaces are unoccupied, there are not significant demand savings. There are also no gas savings.

Table 4-23. Estimation of Savings Attributable to Bi-Level Lighting Control Credits

Type of Space	Expected Annual Lighting Use for Space Likely to be Controlled	Savings Resulting from Lighting Controls	Savings Allocated to Control Credits	Savings Attributable to CASE Initiative
Office	76,895,179	24,606,457	15,379,036	9,227,421
Corridors	417,768	208,884	104,442	104,442
Library stacks	3,125,970	1,562,985	781,492	781,492
Warehouse spaces	13,549,371	4,064,811	2,032,406	2,032,406
Totals	93,988,287	30,443,137	18,297,376	12,145,761

4.4.6 Savings Estimates for Ducts and Attics in New Light Commercial Buildings

Under this revision to the 2005 standards, new light commercial buildings with more than 25% of the ducts outside of directly or indirectly conditioned space are required to have the ducts in this location tested and sealed to 8% total leakage and to have duct insulation of R-8. By contrast, required duct insulation was R-4.2 under the 2001 standards; ducts were then assumed to have 36% leakage.

Data from the NonResidential New Construction database were used to estimate the savings attributable to this code change. Buildings in the NRNC database with packaged HVAC equipment and with some unconditioned space were identified to form the analysis data set. For each of these buildings, the estimate of annual kWh for cooling that is included in the NRNC database was extracted. As part of their impact analysis, Eley Associates developed estimates of heating and cooling duct efficiencies for 16 climate zones under both 2001 and 2005 standards.

(See page 34 of Eley impact report.) Since the climate zone was known for each building in the analysis set, zone-specific cooling duct efficiency estimates for 2001 could be applied to the cooling kWh for each building to estimate the cooling load. The zone-specific cooling duct efficiency for 2005 could then be applied to the implied cooling load to estimate cooling kWh under the 2005 standards. The difference between the NRNC estimate of cooling kWh and the cooling kWh calculated using the 2005 duct efficiency estimate was then calculated as the savings attributable to the improvement in duct efficiency.

Case weights for the buildings in the analysis data set were applied to develop estimates of savings for the population of newly constructed commercial buildings represented in the NRNC database. However, the total square footage of buildings represented in the NRNC is about 233 million square feet. In Eley Associates' impact report, annual nonresidential new construction is estimated to be 159 million square feet. Accordingly, the savings estimates arrived at by applying the case weights were multiplied by 0.68 (=159/233) to make the savings estimates consistent with those taken from the impact report.

The resulting estimates of savings attributable to the CASE initiative for duct testing and sealing for new commercial buildings are shown by building type in Table 4-24. Annual kWh savings from duct testing and sealing in new light commercial buildings is estimated to be about 8.0 GWh.

Table 4-24. Estimated Savings from Duct Testing and Sealing in New Light Commercial Buildings

Type of Building	***Estimated Savings***
C&I Storage	1,139,476
Grocery Store	1,528,747
General C&I Work	503,629
Medical/Clinical	61,835
Office	2,323,605
Other	232,104
Religious Worship, Auditorium, Convention	49,710
Retail and Wholesale Store	1,780,808
School	58,447
Fire/Police/Jails	145,018
Community Center	188,559
Gymnasium	727
Total	8,012,665

4.4.7 Savings Estimates for Cooling Tower Applications

Several proposals for code changes applying to cooling towers that were made in a CASE report[18] were adopted for the 2005 code revisions. These cooling tower applications included the following:

[18] PG&E, *Code Change Proposal for Cooling Towers*, April 2002.

- A limitation on application of air-cooled chillers was adopted such that chiller plants over 300 tons must limit air cooled chillers to 100 tons or less; the remainder of the capacity must be provided through water-cooled equipment.
- A limitation on the use of centrifugal fans for cooling towers was adopted such that cooling towers serving loads 300 tons and greater must use propeller fans not centrifugal fans.
- A requirement was adopted that multi-cell cooling towers be configured to run in parallel under partload conditions.

Savings estimates for these individual changes were not reported in the impact report prepared by Eley Associates, but the methods used to analyze the impacts of these cooling tower applications were described in the report. Those descriptions are used here to develop independent estimates of the savings attributable to two of these cooling tower applications: the limitation on application of air-cooled chillers and the limitation on use of centrifugal fans. These applications are hardware installs that should result necessarily in savings to the extent that they replace air-cooled condensers. However, savings from the third application depends not only on hardware installation but also on appropriate controls.

To estimate the savings from limiting the application of air-cooled chillers, data was extracted from the Nonresidential New Construction database for all chiller plants with 300 or more tons of capacity. These data were inspected to identify which chiller plants were air-cooled and which had cooling towers. For these sites, their case weights were applied to the NRNC estimates of cooling kWh and site square footage to determine population estimates of cooling energy use for sites with chiller plants with more than 300 tons. These estimates are reported in Table 4-25.

Table 4-25. Square Footage and Cooling kWh for Sites with Chiller Plants with Capacity Greater than 300 Tons

Business Type	***Chillers with Cooling Towers***		***Chillers without Cooling Towers***	
	Square Footage	***Cooling kWh***	***Square Footage***	***Cooling kWh***
C&I storage	1,496,724	4,354,389		
General C&I work	1,351,269	10,414,571		
Medical/clinical	1,912,227	8,824,611	125,568	1,584,571
Office	8,286,704	13,273,072		
Religious worship, auditorium, convention	121,512	336,722		
Retail and wholesale store	1,185,484	2,607,377		
School	194,013	671,438		
Fire/police/jails	385,000	1,792,984		
Libraries	643,234	1,041,131	60,348	102,821
Not known	3,262,235	14,440,721		
Totals	18,838,402	57,757,017	185,916	1,687,391

An estimate of the savings that can be attributed to the limitation on the use of air-cooled chillers can be obtained by considering what the cooling kWh would be if sites without cooling towers were replaced by sites with cooling towers.

- For the medical/clinical business type, sites with cooling towers use 4.61 kWh per square foot for cooling while sites without cooling towers use 12.62 kWh per square foot for cooling. Thus, if sites without cooling towers used the same energy for cooling as sites with cooling towers, electricity use for cooling would drop from 1,584,571 kWh to 579,475 kWh, giving a savings of 1,005,095 kWh.
- For libraries, sites with cooling towers use 1.62 kWh per square foot for cooling while sites without cooling towers use 1.70 kWh per square foot for cooling. Thus, if sites without cooling towers used the same energy for cooling as sites with cooling towers, electricity use for cooling would drop from 102,821 kWh to 97,678 kWh, giving a savings of 5,142 kWh.

Based on these calculations using data from the NRNC database, annual savings from limiting the use of air-cooled chillers would be about 1.0 GWh (i.e., 1,005,095 + 5,142 = 1,010,238).

Another provision adopted for the 2005 code revision was a limitation on the use of centrifugal fans for cooling towers. Under this provision, cooling towers serving loads 300 tons and greater must use propeller fans not centrifugal fans. To develop an estimate of the savings from this provision, data were extracted from the Nonresidential New Construction database for sites with chillers and cooling towers where the chiller capacity was 300 tons or more. The NRNC database contain information on the horsepower of cooling tower fans, but does not contain information on whether the fans are centrifugal or propeller. However, the horsepower information was used along with the information on chiller capacity to impute the type of fan.

The imputation procedure used was as follows. The required horsepower for cooling tower fans can be determined by dividing the rated gpm capacity of the cooling tower by the gpm per horsepower provided by a particular type of fan. The rated gpm capacity of a cooling tower can be determined by multiplying chiller tonnage by 24[19] and dividing by the "delta T" temperature differential. Thus, for a 300 ton chiller, the rated gpm of the associated cooling tower for a ten degree temperature differential is 300*24/10 = 720 gpm.

Per the impact report prepared by Eley Associates (pages 30-31), the minimum gpm per hp is 38.2 for propeller fans and 20 for centrifugal fans. Thus, if propeller fans were used for a cooling tower rated at 720 gpm, the required horsepower would be 18.85. If a centrifugal fan were used, the required horsepower would 36. By comparing these required horsepowers for different kinds of fans to the actual installed horsepower, inferences could be drawn about the type of fan being used for each cooling tower. For each cooling tower in the analysis data set, cooling tower fans were imputed as either propeller, centrifugal, or unknown. (For example, fan type was imputed as "unknown" if the actual horsepower of the cooling tower fans was not recorded in the NRNC database.)

[19] = 12,000 Btu/hr/(8.33 lb/gal*60 min/hr)

The NRNC case weights for the various cooling tower observations were used to determine the chiller tonnage and the associated kWh for cooling for cooling towers with different types of fans. These results are reported in Table 4-26. The bottom half of Table 4-26 shows the split between propeller and centrifugal fans when the values for the "Unknown" category are imputed to the Propeller and Centrifugal categories in proportion to the known values. With the unknown values imputed, propeller fans are used for about 85% of cooling tower tonnage, accounting for about 82% of electricity use for cooling.

Table 4-26. Chiller Tonnage and Cooling kWh for Cooling Towers with Different Types of Fans and Chiller Capacity Greater Than 300 Tons

Type of Cooling Tower Fan	***Chiller Tonnage***	***Cooling kWh***
Propeller	78,785	38,972,015
Centrifugal	13,920	8,527,864
Unknown	60,565	10,257,138
Totals	153,270	57,757,017
With Unknown Values Imputed to Propeller or Centrifugal Categories		
Propeller	130,257	47,387,643
Centrifugal	23,013	10,369,373
Totals	153,270	57,757,017

Savings from restricting the use of centrifugal fans can be estimated by considering how electricity use for cooling would drop if propeller fans were used instead of centrifugal fans. From the bottom half of Table 4-25, cooling kWh per chiller ton is 363.8 when propeller fans are used for the cooling towers and 450.6 when centrifugal fans are used. Thus, if the 23,013 chiller tons where centrifugal fans are used were equipped instead with propeller fans, electricity use for cooling would be 8,372,293 kWh (= 23,013 tons x 363.8 kWh per ton). Annual savings from using propeller fans instead of centrifugal fans would be 1,997,080 kWh (=10,369,373 – 8,372,293).

Taken together, the annual savings from limiting the use of air-cooled chillers and of centrifugal fans would be about 3.0 GWh (= 1,010,238 kWh + 1,997,080 kWh = 3,007,318 kWh).

4.5 SUMMARY OF EXPECTED SAVINGS FROM CODE REVISIONS ATTRIBUTABLE TO C&S PROGRAM

The preceding sections have examined the savings from code revisions whose inclusion in the 2005 energy efficiency standards can be attributed to the efforts of the C&S Program. Estimates of the annual energy savings from the code changes being developed for implementation in 2005 have been reviewed in the preceding discussion. Based on this review, estimates of the expected annual savings from the code revisions attributable to the C&S Program are summarized in Table 4-27.

Table 4-27. Expected Annual Savings Estimates for Proposed Changes to 2005 Energy Efficiency Standards Attributable to C&S Program

Sector/Code Revision	***Expected Annual Savings***		
	Electricity (GWh)	***Peak (MW)***	***Natural Gas (Million Therms***
Residential			
Time dependent valuation	6.70	27.20	n/a
Hardwired lighting	64.60	2.97	n/a
Duct improvement	5.70	8.50	1,105,000
Window replacement	6.34	2.40	295,646
Multifamily water heating	n/a	n/a	1,500,000
Subtotal, Residential	83.34	41.07	2,900,646
Nonresidential			
Time dependent valuation	4.30	18.70	n/a
Lighting controls under skylights	25.46	n/a	n/a
Ducts in existing commercial buildings	9.73	7.36	1,035,000
Cool roofs	14.60	9.50	n/a
Relocatable classrooms	2.90	n/a	n/a
Bi-level lighting control credits	12.14	n/a	n/a
Duct testing/sealing in new commercial buildings	8.01	n/a	n/a
Cooling tower applications	3.01	n/a	n/a
Subtotal, Nonresidential	80.15	35.6	1,035,000
Total, Residential and Nonresidential	163.49	76.63	3,935,646

Because several of the code revisions affect primarily existing buildings (e.g., duct sealing for both existing residential and nonresidential buildings, window replacement for residential buildings, and cool roofs for nonresidential buildings), the savings attributed to those revisions may be affected because of the mechanism by which the code revisions will be enforced. That is, the savings that are achieved will depend on the extent to which the code revisions are enforced.

The mechanism for enforcement is generally not a major consideration with code revisions that affect new construction. Indeed, the focus of building codes historically has been on new construction. The infrastructure for enforcing standards for new buildings is well established, and code revisions that affect new construction can usually be accommodated easily within the existing infrastructure.

However, the enforcement mechanism cannot be taken for granted in examining the likely savings from code revisions that affect existing buildings. There are some scenarios where the enforcing of code revisions for existing buildings will be no different than for new buildings.

- In one scenario, households or businesses that are taking actions in existing buildings that come under the purview of the code revisions voluntarily comply with the code requirements by obtaining permits and following the same process as applies when new buildings are involved.
- In another scenario, code enforcement authorities commit to enforcing the code revisions for existing buildings with vigor, even to the extent of setting up procedures to identify when any action occurs that comes under the code revisions and for which a permit has not been obtained.

In general, however, it is more likely that the enforcing of the code revisions for existing buildings will be different than for new buildings. A major reason is that sealing ducts, replacing windows, or replacing roofs for existing buildings are actions that can be and often are undertaken without obtaining permits. Moreover, although the new code provisions for duct sealing are triggered by replacement of heating or cooling equipment, such replacements also often occur without permits. Because most code enforcement agencies in California are strapped for money and resources, there is a question of whether they will be able to vigorously pursue households or businesses who take such actions without permits.

Under these circumstances, compliance with the code becomes subject to market forces. On one side of the market are the demand forces created by households or businesses purchasing the products or services that are the subjects of the code revisions. On the other side of the market are the actions of suppliers in promoting the products or services. In practice, it would be expected that the forces on the supply side will be more important in controlling to what extent and by how much the code revisions are complied with.

- Consider, for one example, the code revision that requires windows being replaced in existing homes to meet the energy efficiency requirements of windows for new buildings. *De facto*, window manufacturers and window contractors could promote the higher efficiency windows, either by using the code requirements to market the higher efficiency windows to customers or even by no longer selling the lower efficiency windows. In this scenario, the manufacturers and contractors would be enforcing the code revisions through their sales and business practices.
- As a contrasting example, consider the code revision that requires duct sealing for existing residential and nonresidential buildings when either heating or air conditioning equipment is replaced. Under the code, duct sealing thus should become an added service when a household or business replaces a piece of HVAC equipment. However, the question that arises is how and to what extent HVAC contractors will use the code requirement in marketing and selling HVAC equipment and services. In effect, this implies that the responsibility for enforcing compliance with the code shifts to the HVAC contractor.

> Moreover, will a contractor refuse to install HVAC equipment for any customer who does not agree to duct testing and sealing?

An implication of this line of argument is that greater uncertainty attaches to estimates of savings resulting from code revisions that affect existing buildings than from revisions that affect new construction.

5. SUMMARY AND DISCUSSION OF RESULTS

The objectives for the evaluation of the 2002 Statewide Codes and Standards Program were threefold:

- To evaluate the codes and standards program processes and program interactions with regulators, stakeholders, and the buildings-related communities;
- To evaluate program impacts and estimate attribution of impacts to C&S program activities; and
- To recommend ways to improve program effectiveness.

The results of this study pertaining to these objectives are summarized and discussed here.

5.1 CODE PROCESS EVALUATION AND SUGGESTIONS FOR IMPROVEMENT

The codes and standards program processes and program interactions with regulators, stakeholders, and the buildings-related communities were evaluated using information gathered through interviews with various stakeholders in the process. Major observations derived from this information include the following:

- There is general agreement that the C&S Program played a central role in the 2005 code revision process. Because of the C&S Program, more code revision proposals could be examined for possible adoption and the depth of research on these proposals was greater.
- Those interviewed generally felt that the CEC code revision process was open. However, most also felt that the process was time-consuming, given the volume of material to be reviewed and the number of workshops being held. Scheduling within the process also was perceived as creating difficulties in that the time allowed for reviewing materials was often too short.
- Perceptions of the code revision process appear to be colored by the amount of experience that an individual or organization has had with the process. Those stakeholders who have been participating in the process over several code revision cycles generally found the process to be relatively open and transparent. Those stakeholders participating in the code revision process for the first time were somewhat more perplexed about the process. They did not have the experience in working with CEC staff or other stakeholders and found the formal process to be less open and transparent.

Interviewees also had suggestions for improving the code revision process. These suggestions pertained to the following:

- Making the process more open and transparent;
- Involving industry in utility work;
- Providing assistance with testing through the program; and

- Providing assistance in training builders and contractors.

5.2 EVALUATING PROGRAM IMPACTS

The code revisions that could be clearly attributed to the C&S program and that provided the most savings included the following:

- Time dependent valuation
- Residential proposals
  - Hardwired lighting
  - Duct improvements
  - Window replacement
  - Multifamily water heating
- Nonresidential proposals
  - Lighting controls under skylights
  - Ducts in existing commercial buildings
  - Cool roofs
  - Relocatable classrooms
  - Bi-level lighting control credits
  - Duct testing and sealing in new light commercial buildings
  - Cooling tower applications

Savings that will result from the adoption of these code revisions can be attributed to the efforts of the C&S Program in general and to research supported by PG&E in particular. Estimates of the savings from these proposals that were developed in CASE reports and in Eley Associates' impact report were reviewed to identify (1) issues that may be associated with the data sources and with the procedures used to prepare the estimates and (2) any anomalous or inconsistent results.

The review of savings estimates revealed the following.

- Estimation of the savings that will result from the adoption into the code of Time Dependent Valuation will be speculative at this point in time. TDV changes the calculus whereby builders determine what combinations of energy efficiency measures they will incorporate into new buildings. Because savings estimates must be tied to specific measures, the fact that the combinations that will actually be used are not yet obvious makes estimation of savings problematic.
- Major differences in estimates of aggregate savings between CASE reports and the impact report were identified for several measures, including duct sealing and window replacement for existing houses. These differences were mainly attributable to different estimates about the number of houses that would be affected by a particular code revision. In general, the

aggregate savings estimates in the impact report were lower than those developed in the CASE reports.

- Estimates of aggregate savings for code revisions affecting existing buildings are more uncertain than those for revisions affecting new construction because the infrastructure for enforcement of code requirement for existing buildings is less well developed than for new construction.

This review was used to develop alternative estimates of savings, where appropriate. The alternative sets of savings estimates are shown in Table 5-1, which compares the initial estimates of savings calculated in the impact report (and as reported in Table 4-2) and the revised estimates developed through this study. Several observations can be made from comparisons of estimates in Table 5-1.

- For the residential sector, the estimates of kWh and therm savings from this study are lower than the estimates from the impact report, but the estimate of peak demand reduction is higher. The peak demand reduction estimate from this study is higher because estimates for the impacts of time dependent valuation were included.
- For the nonresidential sector, the estimates of kWh savings and peak demand reductions from this study are higher than the estimates from the impact report. The estimates of therm savings are the same. The estimate of kWh savings from this study is higher primarily because the savings lighting controls under skylights are included. The estimate of peak demand reduction is higher because the impacts of time dependent valuation are considered.
- The C&S code revisions that were adopted into the code were primarily developed through research that was supported by PG&E through its C&S Program.

Table 5-1. Comparison of C&S Code Revision Savings to All 2005 Code Revision Savings Using Savings Impacts from Eley Associates' Impact Report and from This Study[20]

	Estimates from Impact Report			***Estimates from This Study***		
	Electricity (GWh)	***Peak (MW)***	***Natural Gas (Therms)***	***Electricity (GWh)***	***Peak (MW)***	***Natural Gas (Therms)***
Residential C&S code revisions	106.08	29.67	4,515,076	83.34	41.07	2,900,646
All 2005 residential code revisions	140.01	93.10	8,500,000	117.27	104.50	6,885,570
Percent from C&S code revisions	76%	32%	53%	71%	39%	42%
Nonresidential C&S code revisions	27.43	16.86	1,035,000	80.15	35.56	1,035,000
All 2005 nonresidential code revisions	338.20	88.30	300,000	367.76	107.00	300,000
Percent from C&S code revisions	8%	19%	n/a	22%	33%	n/a
All C&S code revisions	133.51	46.53	5,550,076	163.49	76.63	3,935,646
All 2005 code revisions	478.21	181.40	8,800,000	485.03	211.50	7,185,570
Percent from C&S code revisions	28%	26%	63%	34%	36%	55%

[20] Because savings estimates for C&S code revisions are included in the "All Code Revisions" estimates, changes in the estimated C&S savings between the impact report and this study cause the numbers for the "All Code Revisions" rows to change as well.

APPENDIX A: REVIEW OF APPROACHES TO ATTRIBUTING SAVINGS

At the planning stage for this study, several approaches were proposed for attributing savings to the C&S Program. On further review, however, application of these approaches did not appear warranted. This appendix describes these alternative approaches and discusses the constraints on their use for this study.

- Section A.1 reviews an attribution methodology that was developed by the Heschong Mahone Group. This methodology was initially developed for attributing savings to the C&S Program efforts pertaining to code changes made for the AB970 code revision process.
- Section A.2 presents and discusses a more general framework for assessing and attributing the impacts of the C&S Program.

A.1 REVIEW OF AB970 ATTRIBUTION METHODOLOGY

In earlier work related to Title 24 code revisions, the Heschong Mahone Group developed a methodology for attributing savings to the C&S Program that it applied to 2001 code changes.[21] This section reviews that methodology regarding its application to the 2005 code revision proposals.

HMG developed and applied an attribution methodology for specific code improvements that were generated out of the C&S program and that actually passed through the code adoption process for the AB970 code update. Because that code revision cycle operated under some time pressure, the work of proposing and developing code revisions was done more collectively among the CEC staff, utility staff, and other stakeholders. With all parties working together to develop the proposed code revisions, it was necessary to consider a number of factors in order to determine how much the utilities' work contributed to the development and adoption of a particular revision.

The methodology developed by HMG was based on considering utilities' participation in ten different steps that were involved in the development and adoption of individual code improvements. Various factors were considered to determine what percentage of the savings resulting from a code improvement could be attributed to the C&S program. Factors considered include the following:

- Developed testing or measurement standards;
- Funded research into testing and measurement;
- Worked with organizations that developed test standards;
- Originated suggestion for standard;

[21] Heschong Mahone Group, *CA IOU Codes and Standards Earnings Claims Framework, Final Report.* Prepared for Pacific Gas and Electric Company, October 2001.

- Conducted technical evaluation;
- Prepared Codes and Standards Enhancement (CASE) study;
- Sponsored market transformation (MT) Programs;
- Hosted meeting and/or conference calls of key stakeholders;
- Drafted code language; and/or
- Appeared at public workshops and hearings.

One of the principal advantages of the HMG methodology is that input from the IOUs' C&S programs can be accounted for even if the C&S team did not take primary responsibility of the code change throughout the process. With the HMG methodology, it was assumed that there are no cases of code revision proposals where the utilities' C&S Program deserves 100% of the credit. Indeed, in some cases, the utilities may play no role and are not assigned any credit.

However, in applying the methodology, subjective judgments need to be made in assigning percentage contributions to the support that the C&S Program provided for the adoption of any particular code revision proposal. The degree of subjectivity can be illustrated by considering the application of the HMG methodology to the code revisions proposed for AB970. HMG provided a spreadsheet that showed the ratings assigned to the various factors included in the HMG methodology for different code revisions under consideration in the AB970 proceedings. The data from this spreadsheet were reviewed using a statistical analysis. For this analysis, the values assigned to the various factors for the different code revision proposals were entered as explanatory variables into a regression analysis. This analysis was intended to provide regression coefficients that would replicate the relative weightings for the various factors within the HMG methodology. The results of the regression analysis are shown in Table A-1.

The regression analysis shows that the overall regression explains about 82.4% of the variation in the contribution scores that HMG assigned to the various AB970 code revision proposals. On the other hand, only three variables have estimated coefficients that are significantly different from 0 at the 90% confidence level. Moreover, one of these variables has a negative coefficient.

These results point up that the HMG methodology in application relies not simply on a mechanistic scoring equation, but more on the judgment of the analyst(s) assigning the final scores as to the contribution of the C&S Program. In that sense, the various factors that are examined are useful in focusing an analyst's thought process on how the C&S Program impacted any particular code revision proposal. However, two individuals looking at the same set of factors can come up with different scorings at to the contribution that the C&S program made to the development and adoption of a particular code revision.

Table A-1. Results of Regression Analysis from Applying HMG Attribution Methodology to AB970 Proposed Code Revisions

Parameter	Estimated Coefficient	Standard Error	T Value	Pr > |t|
Intercept	-0.0097	0.0527	-0.184	0.855
Developed testing or measurement standards	0.1414*	0.0828	1.707	0.099
Funded research into testing/measurement	-0.2454*	0.1074	-2.285	0.030
Worked with organizations that developed test standards	0.1127	0.0843	1.337	0.192
Originated suggestion for standard	0.1719*	0.0889	1.934	0.063
Conducted technical evaluation	0.1196	0.0727	1.646	0.110
Prepared CASE study	0.0791	0.1031	0.767	0.449
Sponsored MT Programs	0.0836	0.0726	1.152	0.259
Hosted meeting and/or conference calls of key stakeholders	0.2870	0.1915	1.499	0.145
Drafted code language	0.0278	0.1602	0.174	0.863
Appeared at public workshops or hearings	0.0304	0.0746	0.408	0.686
Number of observations: 40				
Mean of dependent variable: 0.2525				
R-squared: 0.824		Root Mean Square Error: 0.3927		

*Coefficient significantly different from 0 at 90% confidence level.

A.2 GENERAL FRAMEWORK FOR ASSESSING AND ATTRIBUTING IMPACTS FROM C&S PROGRAM

A decision theory approach provides a general framework for assessing and attributing impacts to a program such as the C&S Program that produces additional information that can be used in decisionmaking. The decision theory approach can be summarized as follows. A variety of actions are open to a decisionmaker. Several states of nature are also possible. The decisionmaker has some knowledge of the likelihood (prior probability) of such states occurring. With a given amount of knowledge, the decisionmaker will choose the action that maximizes expected utility. If additional information becomes available to the decisionmaker and he or she has knowledge of the probability of the information coming true, by Bayes theorem the probabilities of different states occurring are modified and the expected value of a given action revised. The value of information is the difference between the maximum utility with and without the information. This can be compared with the cost of obtaining the information.

An empirical methodology for applying this decision theory approach can be developed from an approach first developed by Daniel McFadden (a winner of the Nobel prize in economics) and later applied by other researchers to evaluate decisions on environmental regulations.[22] With this approach, data sets about some performance measures of regulation are used in trying to identify the statistical determinants of the outcome. Various statistical models are fit to the data, depending on whether the decision being analyzed is discrete (yes/no) or continuous. The basic approach is to ask if the outcome of a decision depends statistically on some aspects of the process or information, while simultaneously taking into account other factors that might affect the outcome. The resulting analysis identifies which factors are statistically associated with the decision, how large an impact a changes in different factors have on the decision, and the overall predictive power of the statistical equation that links the decision indicator to the explanatory factors.

The argument on which this methodology is based can be particularized to the examination of the expected savings from any given code improvement proposed for the CEC's 2005 code revision process. In particular, the expected savings for a proposal is the product of four factors:

- The California Energy Commission began the 2005 code revision process by asking interested parties to propose any code improvements that they thought should be considered. Thus, the first factor is the probability that a code improvement will be proposed for consideration in the code revision process.
- The second factor is the probability that a proposed code improvement would pass the CEC screening and be accepted for more detailed analysis and consideration.
- The third factor is the probability that a code improvement that receives detailed analysis is accepted and adopted into either the buildings or appliances code.

---

[22] Examples of such studies include the following:

McFadden, Daniel (1976), "The Revealed Preferences of a Government Bureaucracy: Empirical Evidence," *Bell Journal of Economics*, 7, pp. 55-72.

Congleton, Roger, ed. (1996) *The Political Economy of Environmental Protection*, University of Michigan Press, Ann Arbor.

Cropper, Maureen, et al. (1992), "The Determinants of Pesticide Regulation," *The Journal of Political Economy*, 100(1).

Farrow, Scott (1991),"Does Analysis Matter? Economics and Planning in the Department of the Interior," *The Review of Economics and Statistics*, 78, pp. 172-176.

Magat, Wesley A., Alan J. Krupnick and Winston Harrington (1986), *Rules in the Making: A Statistical Analysis of Regulatory Agency Behavior*, Resources for the Future, Washington, D.C.

Van Houtven, George (1996),"Bureaucratic Discreation in Environmental Regulations" in *The Political Economy of Environmental Protection*, Roger Congleton, Ed., University of Michigan Press, Ann Arbor.

Viscusi, W. Kip and James T. Hamilton (1999), "Are Risk Regulators Rational?" *The American Economic Review*, 89, pp. 1010-1027.

- The fourth factor is the amount of savings that will be realized from the adopted code improvement.

For this methodology, it can be argued that the values for the three probabilities are affected by whether or not the particular step toward a code improvement is the product of the C&S Program. In particular, if the C&S Program is to have a positive impact on energy savings, the three probabilities should be higher for a code improvement that has received support through the C&S Program than for one that has not. The essence of the approach is to compare the expected savings for a code improvement under two sets of conditions: if the improvement has support through the C&S Program and if it does not. Expected savings for each set of conditions are given by:

Expected savings with C&S Program support = $P_{1, CS}$ x $P_{2, CS}$ x $P_{3,CS}$ x Savings
Expected savings without C&S Program support = P_1 x P_2 x P_3 x Savings

To the extent that P_1 and P_2 and P_3 are greater than 0, then part of the expected savings that come with C&S Program support would have come anyway, naturally. The percentage of savings attributable to C&S Program support is given by:

Percent of savings attributable to C&S Program support = 1 – (P_1 x P_2 x P_3 / $P_{1, CS}$ x $P_{2, CS}$ x $P_{3, CS}$)

To apply this proposed methodology to any particular code improvement, the three probabilities need to be estimated for two cases:

- What is a probability if the improvement has support through the C&S program?
- What is a probability it does not?

Estimates of these probabilities could be developed in two, complementary ways. The first way (discussed in this section) would be through an analysis of the actual set of code improvements submitted for consideration in the 2005 code revision process. The second way (discussed in the next section) would be through a Delphi process with experts in the code revision process.

A.2.1 Statistical Methodology for Applying Decision Theory Approach

A statistical examination would be made of how code improvements that were submitted with and without support from the C&S Program passed through the CEC's code revision process. The set of 271 code improvement suggestions that were submitted to the CEC for consideration in the 2005 code revision process is used for this examination.

Conceptually, it is possible to hypothesize that a code revision would have a higher probability of being submitted to the CEC for consideration if the proposed revision had received support through the C&S Program. That is, to the extent that development of a proposed revision requires funding for preparatory work, the budget support available through the C&S Program would be expected to increase the probability that the revision would be suitably documented for submission to the CEC. However, statistical estimation of this probability is difficult because there are no readily available data on revisions that were considered but not submitted.

Accordingly, the statistical estimation of the probabilities applies to the following questions:

- Was or was not a proposed code improvement accepted for further analysis?
- Was or was not a code improvement accepted for analysis also recommended for inclusion in the code?

Binary choice econometric models can be used to explain acceptance or rejection of a code improvement proposal at these two stages of the code revision process. Among binary choice models, the logistic model has several attractive features. There has been much work that shows that applying the logistic binary choice model to data on individual choices is an efficient method of determining what characteristics determine those choices. With the logistic model, the natural logarithm of the odds that a proposed code improvement will be accepted for the next stage of the process is postulated to be a linear function of a set of observed characteristics of each proposed improvement. For each stage of the code revision process, a logistic model is specified as follows:

$$\ln \frac{P_i}{1-P_i} = \sum_{j=1}^{k} \beta_j X_{ij}$$

where P_i is the probability that the ith proposed code improvement will be accepted for the next stage in the process; the X_{ij}'s are j observed characteristics of the ith proposed code improvement; and the β_j's are parameters to be estimated. By examining the estimates of the β_j's, it can be determined which of the characteristics are most important in determining whether a proposed code improvement will be accepted for the next stage of the code revision process.

The application of this model formulation can be illustrated by considering the estimation of the probability that one of 271 proposed revisions submitted to the CEC was one of the 28 selected by the CEC for further study. Thus, there are 28 revisions for which P = 1 (i.e., the revision was selected for further study) and 243 for which P = 0 (i.e., the revision was not selected). Various variables are then used to explain these probabilities.

- One set of characteristics that could be included as explanatory variables in the model are indicator (0-1) variables showing from whom a proposal received support. Most obviously, one indicator variable can show whether or not a proposed change received support through the C&S Program. Other indicator variables show whether or not the change received support from other sources (e.g., one indicator variable for whether a change was proposed by the CEC, another variable if the change was proposed by another party, etc.).
- A second set of indicator variables can be included to address "horsetrading" back and forth between the CEC, the IOU C&S Programs, and others. For example, some of the IOU C&S templates were "adopted" by the CEC team and staff in an allocation of resources that offered the highest success probability for the highest number of code changes. For these situations, an indicator variable can be included for each C&S Program proposal that was dropped by the IOU team because the CEC indicated that it would make the proposal.

- Another indicator variable to include is for whether or not the CEC made a commitment during the AB 970 Standards proceeding to address the proposed revision in the 2005 round of Standards changes.
- Indicator variables can also be included that relate to preparatory work that was supported through the C&S Program. For example, an indicator variable can be included to show whether a proposed revision was made by an organization (e.g., NFRC, CRRC, ASAP) that received support from the C&S Program for work that went into developing the proposed revision. Similarly, indicator variables can be assigned for the factors that HMG included in their attribution methodology (e.g., whether the C&S Program helped develop testing procedures, whether the program supported organizations that created testing procedures, etc.).
- Also included as possible explanatory variables are quantitative variables that measure such factors as (1) the amount of public funds invested by CEC in developing the proposed revision, (2) the amount of public goods funding through public goods charges, (3) the energy savings expected to be achieved by the proposed revision; and (4) the expected demand reductions.
- Other factors may be included as explanatory variables after review of the program and CEC documentation on the proposed revisions. Such variables may be included to capture the possible effects of external influences beyond the control of the utilities and of support that a utility provided to others that was essential to their development of a proposed revision.

A.2.2 Attribution Methodology Using a Delphi Approach

A second, complementary way to estimate the probabilities that a proposed code improvement will be accepted or rejected at each stage of the code revision process would be to use a Delphi-like process. With the Delphi approach, a panel of experts on the formulation and application of California's buildings and appliances codes is selected. In an iterative process, these experts are presented with the set of code improvements with C&S Program support and are asked to estimate the six probabilities that the methodology requires for each improvement. That is, for each C&S supported code improvement the experts are asked to provide estimates of the following probabilities with and without C&S Program support:

- Probability that a code improvement will be proposed for consideration in the code revision process;
- Probability that a proposed code improvement would pass the CEC screening and be accepted for more detailed analysis and consideration; and
- Probability that a code improvement that receives detailed analysis is accepted and adopted into either the buildings or appliances code.

The main steps in the Delphi process are as follows:

- Identify and select the code improvements for which data need to be collected;
- Identify and select the panel of industry experts;

- Construct the draft of the first-round questionnaire for eliciting information on the probabilities of acceptance/rejection for the targeted code improvements;
- Refine the questionnaire with selected experts;
- Circulate refined first-round questionnaire to all experts to collect first-round estimates of probabilities;
- Synthesize and analyze first-round data estimates of probabilities;
- Construct second-round questionnaire for evaluating first-round estimates;
- Circulate second-round questionnaire to all experts to collect any revised estimates of probabilities of acceptance/rejection;
- Synthesize and analyze second-round data estimates of probabilities;
- Review second-round estimates and determine final estimates;
- Prepare documentation of procedures and results

These steps are discussed in turn.

Industry experts are identified and selected to form a panel for preparing estimates of the probabilities of code improvement acceptance/rejection. Since the judgments of the experts chosen for the panels are the basis for preparing the probability estimates, it is important that those chosen as experts have relevant experience and familiarity with the code revision process. There is a readily identifiable group of experts from which this panel can be selected, comprised of those who have actively participated in the code revision process by submitting proposed improvements or by participating in CEC workshops.

Considerations that come into play in selecting the number of experts to include on the panel include the amount of time the experts will be required to spend, the complexity of managing the panel, and the concern about unduly interfering with the experts' business activities. Because the panel does not need to be statistically representative, a panel of 15 to 20 will be selected. The list of experts proposed for the panel will be provided to the Study Manager and the C&S Program managers, who can recommend additions to or deletions from the proposed panel.

Eliciting information on the targeted code improvements from the industry experts will require a carefully honed questionnaire. The questionnaire is prepared making use of recently developed techniques for eliciting information from experts.[23] Because of the importance of using carefully

---

[23] For examples, see the following:

Meyer, M.A. and Booker, J.M., *Eliciting and Analyzing Expert Judgment: A Practical Guide*, Knowledge Acquisition for Knowledge-Based Systems series, 5 (London, United Kingdom: Academic Press), 1991.

Booker, J. M. and Meyer, M.A., "A Framework for Using Expert Judgment as Data," *Statistical Computing and Statistical Graphics Newsletter*, 2, 9-14, 1991.

Meyer, M.A., Booker, J.M., and Bradshaw, J.M., "A Flexible Six-Step Program for Defining and Handling Bias in Knowledge Elicitation," LA-UR-90-294, *Current Trends in Knowledge Acquisition*, Wielenga, et al. Eds., prepared questionnaires, the assistance of Mr. Jeffrey Johnson and several other selected experts is drawn on to refine the questionnaire.

After the first-round questionnaire has been refined, it is circulated to all experts to collect first-round estimates of probabilities of acceptance/rejection for different code improvements. After the first-round questionnaires are returned, the estimates are summarized and analyzed to arrive at a range of estimates of acceptance/rejection probabilities for the different code improvements. From this, a new, second-round questionnaire is produced that shows the ranges of estimates from the first round and asks the experts to review and evaluate these estimates. Each expert is thus given a chance to complete a new questionnaire revising his or her first-round estimates based on the estimates made by the other experts. The aim of this procedure is to get the experts to come to "consensus" estimates of probabilities. In preparing the consensus estimates, the experts' responses are examined with respect to their level of knowledge, level of activity in the field, and length of time they have been in the field. This examination of responses is conducted in conjunction with the Study Manager and personnel from the C&S Programs.

As the final step, documentation is prepared of the procedures used to develop the estimates and of the results. The consensus estimates then provide inputs for the savings attribution analysis.

A.2.3 Applicability of Decision Theory Approach to This Study

The decision theory approach represents primarily an *ex ante* view of the state of the world regarding the effects of information on decisions. As formulated, it allows valuing the expected utility of producing additional information that will inform decisions. For this evaluation of the C&S Program, however, the actual *ex post* results of the C&S efforts could be determined by identifying the code revision proposals that were produced through the C&S Program efforts and actually adopted into Title 24. From this *ex post* perspectives, the results have been determined and probabilistic calculations of expected savings are not required. However, because of its *ex ante* perspective, the decision theory approach does provide a vehicle for examining code revision proposals that might be proposed in the future.

Frontiers in Artificial Intelligence and Applications Series (IOS Press: Amsterdam, The Netherlands), 1990, pp. 237-256.

O'Hagan, A., "Eliciting Expert Beliefs in Substantial Practical Applications," *The Statistician* 47, 21-35, 1998.

APPENDIX B: ANNOTATED BIBLIOGRAPHY

This appendix provides a bibliography of the materials drawn on for the evaluation of the Codes and Standards Program.

Materials on Design, Administration and Evaluation of Utilities Codes and Standards Program:

The materials listed here are background materials regarding the design and development of the Codes and Standards Program, the administration of the program, and the evaluation of its results. The study by Pacific Consulting Services was a study that provided initial information on what the Codes and Standards Program could do. The four ACEEE papers summarize the design and administration of the program. The last three studies provide the first estimates of the savings impacts resulting from the Codes and Standards Program.

Pacific Consulting Services, et al. (1999) *Market Assessment & Evaluation Study in Support of Codes and Standards, Final Report.*

Eilert, P., Horowitz, N., Fernstrom, G., Mahone, D., Stone, N., (2002) “A Strategic Framework for PGC Planning: Strategic Linkages Between Codes and Standards and Resources Acquisition” *Proceedings from the 2002 ACEEE Summer Study on Energy Efficiency in Buildings.* Washington, DC: American Council for an Energy Efficient Economy.

Mahone, D., Blanc, S., Eilert, P., Fernstrom, G., Hunt, M., (2002) “Upgrading Title 24: Residential and Nonresidential Building Energy Standards Improvements in California”, *Proceedings from the 2002 ACEEE Summer Study on Energy Efficiency in Buildings.* Washington, DC: American Council for an Energy Efficient Economy.

Pope, T, Rainer, L., Fernstrom, G., and Eilert, P., (2002) “Minimizing Investments by Investing in Minimums: Energy Savings Through Appliance Standards” *Proceedings from the 2002 ACEEE Summer Study on Energy Efficiency in Buildings.* Washington, DC: American Council for an Energy Efficient Economy.

Stone, N., Mahone, D., Eilert, P., and Fernstrom, G. (2002) “What’s a Utility Codes and Standards Program Worth, Anyway?” *Proceedings from the 2002 ACEEE Summer Study on Energy Efficiency in Buildings.* Washington, DC: American Council for an Energy Efficient Economy.

Heschong Mahone Group, (2001) *CA IOU Codes and Standards Earnings Claims Framework, Final Report.* Prepared for Pacific Gas and Electric Company.

Jacobs, P., and D. Roberts. (2001) “Estimated Impacts of the Non-Residential and Appliance Standards” in *CA IOU Codes and Standards Earnings Claim Framework Final Report.* San Francisco, CA: Pacific Gas and Electric Company.

Nittler, K., Wilcox, B. (2001) “Estimated Impacts of the Residential and Appliance Standards” in *CA IOU Codes and Standards Earnings Claim Framework Final Report.* San Francisco, CA: Pacific Gas and Electric Company.

CASE Studies Prepared for Codes and Standards Program:

One main thrust of the Codes and Standards Program is to prepare studies that evaluate the feasibility and appropriateness of including different energy efficiency enhancements into the Title 24 or Title 20 energy efficiency codes. These studies will provide source material for preparing estimates of the savings impacts of the program. Examples of these CASE studies are listed below.

Pacific Gas and Electric Company (PG&E). (2000) *Energy Efficient Exit Signs Codes and Standards Enhancement (CASE) Study.*

Pacific Gas and Electric Company (PG&E). (2000) *Dry-type Transformers Codes and Standards Enhancement (CASE) Study.*

Pacific Gas and Electric Company (PG&E). (2001) *Code Enhancement Initiative For the AB 970 Emergency Rulemaking - Commercial Clothes Washers.*

Pacific Gas and Electric Company (PG&E). (2002) *Code Enhancement Initiative For PY2001: Title 20 Standards Development - Portable Room Air Cleaners.*

Pacific Gas and Electric Company (PG&E). (2002). *Code Enhancement Initiative For PY2001: Title 20 Standards Development - Water Dispensers.*

Pacific Gas and Electric Company (PG&E). (2002) *Code Enhancement Initiative For PY2001: Title 20 Standards Development - Low-Voltage Wall Transformers.*

Pacific Gas and Electric Company (PG&E). (2002) *Code Enhancement Initiative For PY2001: Title 20 Standards Development - Consumer Electronic Equipment Standby Losses*.

New Buildings Institute, Eley Associates, and Heschong Mahone Group. (2000) *Lighting Controls: Codes and Standards Enhancement (CASE) Study*.

New Buildings Institute, Eley Associates, and California Institute for Energy Efficiency. 2000) *High Albedo (Cool) Roofs: Codes and Standards Enhancement (CASE) Study.*

New Buildings Institute and Eley Associates. (2000) *Dry-type Transformers: Codes and Standards Enhancement (CASE) Study.*

New Buildings Institute, Eley Associates, and Heschong Mahone Group. (2000) *Energy Efficient Exit Signs: Codes and Standards Enhancement (CASE) Study.*

New Buildings Institute, Eley Associates, Architectural Energy Company, and Don Felts Energy Consulting. (2000) *Heating, Ventilation, and Air Conditioning (HVAC) Controls: Codes and Standards Enhancement (CASE) Study.*

Context for Codes and Standards Program: California Energy Use

The savings that will be realized from the Codes and Standards Program activities will be realized over the coming decades. Recent studies that have looked at the current and projected energy use in California therefore provide a context in which to assess the impacts of the Codes and Standards Program. The studies by Bernstein, et al., by Brown and Koomey, and by Global Energy Partners provide evidence on the current state of energy use in California. The study by the California Energy Commission provides an "official" projection of how electricity use will trend over the next ten years. The three studies by Xenergy are useful in that they look at the energy efficiency potential in existing residential and nonresidential buildings. To the extent that the existing stock of buildings is renovated in future years, this will be a significant area where revised energy efficiency standards will be applied.

Bernstein, M., Lempert, R., Loughran, D. and Ortiz, D. (2000) *The Public Benefit of California's Investments in Energy Efficiency.* Report prepared by Rand Corporation for California Energy Commission.

Brown, R. and J. Koomey. (2002) "Electricity Use in California: Past Trends and Present Usage Patterns." *Energy Policy*.

California Energy Commission (CEC) (2003). *California Energy Demand 2003-2013 Forecast*.

Global Energy Partners, LLC (2003) *California Summary Study of 2001 Energy Efficiency Programs, Final Report.*

Rufo, M. and F. Coito, (2002) *California's Secret Energy Surplus: The Potential for Energy Efficiency.* Report prepared by Xenergy, Inc. for The Energy Foundation and The Hewlett Foundation.

XENERGY, Inc. (2002). *California Commercial Sector Energy-Efficiency Potential Study (Existing Construction Only*). Prepared for Pacific Gas and Electric Company.

XENERGY, Inc. (2002). *California Residential Sector Energy-Efficiency Potential Study (Existing Construction Only)*. Prepared for the California Energy Commission.

Context for Codes and Standards Program: Advantages of Using Building and Appliances Codes and Standards to Promote Energy Efficiency

Additional context for the assessment of the Codes and Standards Program is provided by looking at studies that have examined the advantages of using building and appliances codes and standards to promote energy efficiency.

Geller, H. and D. Goldstein. (1998) "Equipment Efficiency Standards: Mitigating Global Climate Change at a Profit." Washington, D.C.: American Council for an Energy-Efficient Economy and San Francisco, CA: Natural Resources Defense Council.

Jones, T., Norland, D., and Prindle, B. (1998) *Opportunity Lost: Better Energy Codes for Affordable Housing and a Cleaner Environment.* Washington, D.C.: Alliance to Save Energy.

Moyes, R., (1999) *Standards in the Residential Construction Industry: Key Issues.* Report prepared for Canadian Home Builders' Association.

Appliance Standards Awareness Project (ASAP) (2000) "Opportunity Knocks: Capturing Pollution Reductions and Consumer Savings From Updated Appliance Efficiency Standards." Washington, DC: American Council for An Energy-Efficient Economy

Johnson, J., Nadel, S. (2000) "Commercial New Construction Programs: Results from the '90s, Directions for the Next Decade" in *Proceedings from the 2000 ACEEE Summer Study on Energy Efficiency in Buildings*. Washington, D.C.: American Council for an Energy Efficient Economy.

The Allen Consulting Group (2002) *Cost-Benefit Analysis of New Housing Energy Performance Regulations: Impact of Proposed Regulations.* Report for The Sustainable Energy Authority and The Building Commission (Australia).

CEC Materials for Update of 2005 Energy Efficiency Buildings Standards:

Recent activities of the Codes and Standards Programs have been directed at supporting the 2005 Update to the Energy Efficiency Building Standards. The California Energy Commission, which is in charge of the updating, has posted documents and presentations for the 2005 Update at the following url:

http://www.energy.ca.gov/2005_standards/documents/index.html

These documents include CASE studies developed with support of the Codes and Standards Program along with other documents evaluating proposed revisions to the standards. These materials will provide information on the applicability and expected savings of different measures.

A listing of the documents is as follows:

Document	*Date Online*
Top 28 Committee-Selected Priority Measures for 2005 Standards Changes	March 14, 2002.
Related Proposals to Priority Measures.	October 22, 2002.
Compliance Using Ducts Buried in Attic Insulation	February 11, 2003
Errata and Additions to the 2/4/03 Workshop Draft of the 2005 Building Energy Efficiency Standards.	February 6, 2003
Duct Sealing Requirements upon HVAC or Duct-System Replacement: Light Commercial Buildings	January 28, 2003
Nonresidential Duct Sealing and Insulation	January 28, 2003.
2005 Building Energy Efficiency Standards - Joint Appendices.	January 23, 2003
Nonresidential ACM Manual	January 23, 2003
Residential ACM Manual	January 23, 2003
Draft 3 of the 2005 Energy Efficiency Standards for Residential and Nonresidential Buildings	January 22, 2003
ACM Draft - Tables B10 and B11	November 7, 2002
Draft 2 of the 2005 Energy Efficiency Standards for Residential and Nonresidential Buildings	November 4, 2002
Appendix NJ - Acceptance Requirements for Nonresidential Buildings	October 22, 2002
Residential Errata to 10/22/02 Drafts	November 19, 2002
Memorandum from Jeff Johnson, New Buildings Institute, Re: ACM Manual Appendix - Acceptance Testing	October 31, 2002
2005 Energy Efficiency Standards for Residential and Nonresidential Buildings - Workshop Draft	October 22, 2002
2005 Residential ACM Manual - Workshop Draft	October 22, 2002
Appendix NJ - Acceptance Requirements for Nonresidential Buildings	October 22, 2002
Part IV: Measure Analysis and Life-Cycle Cost.	August 14, 2002
Inclusion of Cool Roofs in Nonresidential Title 24 Prescriptive Requirements - Revised August 2002	August 14, 2002.
Gas Cooling Compliance Options for Residential and Non-Residential	August 14, 2002

Document	*Date Online*
Buildings - Interim Report	
Measure Analysis and Life-Cycle Cost	July 3, 2002.
Bi-Level Lighting Control Credits	July 3, 2002
Duct Sealing Requirements upon HVAC or Duct-System Replacement: Light Commercial Buildings	July 3, 2002
Nonresidential Duct Sealing and Insulation	July 3, 2002
High Performance Relocatable Classrooms	July 3, 2002
Measure Analysis and Life-Cycle Cost -- Residential Fenestration and Hydronics.	May 17, 2002
Code Change Proposal, Duct Sealing Requirements upon HVAC or Duct-System Replacement.	May 17, 2002
Code Change Proposal, Hourly Water Heating Calculations.	May 17, 2002
Code Change Proposal, Inclusion of Cool Roofs in Nonresidential Title 24 Prescriptive Requirements.	May 17, 2002
Code Change Proposal, Multifamily Water Heating.	May 17, 2002
Code Change Proposal, Residential Hardwired Lighting.	May 17, 2002.
Code Change Proposal, Updates to Title 24 Treatment of Skylights	May 17, 2002
Workshop Report for Review - Measure Analysis and Life-Cycle Cost: Lighting Power Allowances, Demand Control Ventilation, Construction Quality (walls), Water Heating Distribution.	
Code Change Proposal for Cooling Towers	
Code Change Proposal for Window Efficiency Requirements Upon Window Replacement	
Workshop Report for Review - Acceptance Requirements for Nonresidential Buildings -- Consultant Report Prepared by New Buildings Institute, Inc.	April 11, 2002
Residential Computer Modeling Draft Report	
Life Cycle Cost Methodology Report	
Time Dependent Valuation - Economics Methodology	
Measure Identification and Analysis Plan - Draft Report Revised report	November 9, 2001
Characterization of Framing Factors For Low-Rise Residential Building Envelopes In California	November 7, 2001
Measure Information Template - A template of the information necessary to complete a preliminary evaluation of proposed changes to the 2005 Building Energy Efficiency Standards.	October 16, 2001

Data Sources on Energy Use in California Buildings:

A number of major data collection projects have been conducted over the past several years to provide data on the characteristics of residential and commercial buildings and the energy-using equipment in these buildings. These studies will provide information with which to evaluate current saturations and projected market penetration rates for different types of energy efficiency measures.

Residential Data Sources:
- Statewide Residential Lighting and Appliance Survey (RLW Analytics)
- California Statewide Residential Sector Energy Efficiency Potential Study (Xenergy)
- Residential Efficiency Market Share Tracking Study (RER)
- 2001 DEER Update Study (Xenergy)
- Residential New Construction Study (RER)
- Multifamily Common Area/Builders Survey (ADM)
- Multifamily Building New Construction Characteristics Study (RER)

Nonresidential Data Sources:
- Nonresidential new construction database study (RLW Analytics)
- NRNC Market Characterization and Program Activities Tracking Study (Quantum Consulting, Inc.)
- Nonresidential remodeling and renovation study (ADM)
- California Statewide Commercial Sector Energy Efficiency Potential Study (Xenergy)
- 1999 State-Level Small/Medium Nonresidential Market Assessment and Evaluation Study (Xenergy)
- PG&E and SDG&E Commercial Lighting Market Effects Study (Xenergy)

Economists Looking at Impacts of Codes and Standards for Buildings:

There have been some studies by economists that look at the impacts that result from regulating through the use of codes and standards rather than using market-based approaches to achieve environmental goals. Overviews of the issues that economists view as important in regulatory activities are provided in the two papers by Hahn and in the paper by Oates and Portney. The other studies listed represent efforts to give empirical evidence on the impacts of regulations that affect energy use in housing. The papers by Quigley report on his studies of the impacts of the building energy efficiency codes that were enacted in California during the 1980's, while the paper by Jaffe and Stavins examined how building code regulations affected the choice of what level of insulation to use in houses. The paper by Newell, Jaffe and Stavins looks at what role energy efficiency standards had *vis-à-vis* changing energy prices and other factors in leading to improvements in energy-using appliances over time. The paper by Hammitt, et al. does not look at energy *per se*, but it does suggest that regulation of housing through tightened building codes can have adverse effects.

Hahn, R. (1990) "The Political Economy of Environmental Regulation: Towards a Unifying Framework". *Public Choice.*

Hahn, R. (1998) "Government Analysis of the Benefits and Costs of Regulation". *Journal of Economic Perspectives.*

Hammitt, J. K., Belsky, E., Levy, J., and Graham, J., (1999) *Residential Building Codes, Affordability, and Health Protection: A Risk-Tradeoff Approach.* Working Paper W99-1. Harvard University: Joint Center for Housing Studies.

Jaffe, A. and Stavins, R. (1994) "Dynamic Incentives of Environmental Regulations: The Effects of Alternative Policy Instruments on Technology Diffusion." *Journal of Environmental Economics and Management.*

Newell, R., Jaffe, A. and Stavins, R., (1998) "The Induced Innovation Hypothesis and Energy-Saving Technological Change," *Quarterly Journal of Economics.*

Oates, W. and Portney, P., (2001) *The Political Economy of Environmental Policy*. Discussion Paper 01–55, Resources for the Future.

Quigley, J. (1984) "Residential Energy Standards and the Housing Market: A Regional Analysis," *Papers of the Regional Science Association.*

Quigley, J. and P. Varaiya, (1989) "The Dynamics of Regulated Markets: Construction Standards, Energy Standards and Durable Goods," in *Advances in Spatial Theory and Dynamics*, edited by A. Andersson.

Quigley, J. (1991) "Market Induced and Government Mandated Energy Conservation in the Housing Market: Econometric Evidence from the U.S." *Review of Urban and Regional Development Studies.*

U. S. DOE Analyses of Impacts of Code Changes:

One of the goals in evaluating the Codes and Standards Program is to develop estimates of the savings that will occur from implementing various revisions. The U.S. Department of Energy has also been working with other states to provide them similar evidence of the energy savings that they might realized from implementing codes that require greater energy efficiency. Examples of such studies are listed here. These studies will provide information with which to develop the methodologies for savings estimation to be used in this evaluation.

Residential:

Lucas, R. (2001) *Assessment of Impacts from Updating Idaho's Residential Energy Code to Comply with the 2000 International Energy Conservation Code.* Report prepared for U.S. Department of Energy by Pacific Northwest National Laboratory.

Lucas, R. (2001) *Assessment of Impacts from Updating Kentucky's Residential Energy Code to Comply with the 2000 International Energy Conservation Code.* Report prepared for U.S. Department of Energy by Pacific Northwest National Laboratory.

Lucas, R. (2002) *Assessment of Impacts from Adopting the 2000 International Energy Conservation Code for Residential Buildings in Illinois (Draft).* Report prepared for U.S. Department of Energy by Pacific Northwest National Laboratory.

Lucas, R. (2002) *Assessment of Impacts from Updating New Mexico's Residential Energy Code to Comply with the 2000 International Energy Conservation Code.* Report prepared for U.S. Department of Energy by Pacific Northwest National Laboratory.

Commercial:

Belzer, D., K. Cort, D. Winiarski, E. Richman, and M. Friedrich, (2002) *Analysis of Potential Benefits and Costs of Adopting ASHRAE Standard 90.1-1999 as a Building Energy Code in Illinois Jurisdictions.* Report prepared for U.S. Department of Energy by Pacific Northwest National Laboratory.

Cort, K. and D. Belzer, (2002) *Statewide Savings Projections from the Adoption of a Commercial Building Energy Code in Illinois*. Report prepared for U.S. Department of Energy by Pacific Northwest National Laboratory.

Cort, K., D. Belzer, D. Winiarski, and E. Richman (2002) *Analysis of Potential Benefits and Costs of Updating the Commercial Building Energy Code in Iowa*. Report prepared for U.S. Department of Energy by Pacific Northwest National Laboratory

Cort, K., D. Belzer, M. Halverson, E. Richman, and D. Winiarski (2002) *Analysis of Potential Benefits and Costs of Adopting ASHRAE Standard 90.1-1999 as a Commercial Building Energy Code in Michigan*. Report prepared for U.S. Department of Energy by Pacific Northwest National Laboratory.

Statistical Analysis of Public Decision Making:

One method to evaluate the impact of the Codes and Standards Program in getting code revisions is to prepare a statistical examination of factors that might influence the decision. The following papers provide examples of how that methodology has been developed and applied to other types of environmental regulation decision making.

McFadden, Daniel (1976), “The Revealed Preferences of a Government Bureaucracy: Empirical Evidence,” *Bell Journal of Economics*.

Congleton, Roger, ed. (1996) *The Political Economy of Environmental Protection*. University of Michigan Press, Ann Arbor.

Cropper, Maureen, et al. (1992), "The Determinants of Pesticide Regulation," *The Journal of Political Economy*.

Farrow, Scott (1991),“Does Analysis Matter? Economics and Planning in the Department of the Interior,” *The Review of Economics and Statistics*.

Magat, Wesley A., Alan J. Krupnick and Winston Harrington (1986), *Rules in the Making: A Statistical Analysis of Regulatory Agency Behavior*, Washington, D.C.: Resources for the Future.

Van Houtven, George (1996),“Bureaucratic Discretion in Environmental Regulations” in *The Political Economy of Environmental Protection*, edited by Roger Congleton, University of Michigan Press, Ann Arbor.

Viscusi, W. Kip and James T. Hamilton (1999) "Are Risk Regulators Rational?" *The American Economic Review*.

APPENDIX C: INTERVIEW GUIDES

This appendix provides the interview guides used for three sets of interviews:

- C&S Program Managers/Staff
- CEC staff involved in code revision process
- Organizations who are stakeholders in CEC code revision process

Draft Interview Guide for C&S Program Managers/Staff

How long have you been employed at [utility]?

How long have you been associated with the C&S Program?

How long have you been the Program Manager for the C&S Program at [utility]?

Were you involved the getting the Statewide C&S Program up and running?
 If so, what was your role?

Were you involved the getting the C&S Program at [utility] up and running?
 If so, what was your role?

What is your understanding of the main goals and objectives of the Statewide C&S Program?

Have these goals and objectives changed since the beginning of the C&S Program?
 In what way have they changed?
 Why have they changed?
 In response to what circumstances?

Although the C&S program is a statewide program, each utility has structured its program so that program components are somewhat different among utilities.
 Identify and describe the major components for the C&S Program at [utility].
 Describe each program component. [Note: Where available, program documentation or literature can be provided to describe a component.]
 What are the program goals addressed by each component.
 How were the program components selected?
 How was the agreement reached among the utilities as to which components each utility would emphasize?

Have the components for the C&S Program at [utility] changed since the beginning of the program?
 If so, how?
 Why were these components changed?

What factors facilitated starting up the C&S Program activities at [utility]?
 What barriers were encountered during implementation?
 How were these barriers overcome?

Please describe the administrative structure that [utility] uses to administer C&S Program activities.
 How many people at [utility] are directly involved in administering the C&S Program?
 What background/experience do the C&S Program staff have?
 Have C&S Program staff received any special training to administer this program?
 Do you think that special training is required?

Please describe the procedures (e.g., workshops, meetings, telephone calls, etc.) that you use to link/coordinate [utility]'s C&S Program activities with those of the other utilities. How well do these procedures work?
 What changes could be made to improve these procedures?

Please describe the procedures (e.g., workshops, meetings, telephone calls, etc.) that you use to link/coordinate [utility]'s C&S Program activities with the activities of the CEC in revising the energy efficiency standards for buildings and appliances.

How well do these procedures work?
What changes could be made to improve these procedures?

Please describe the procedures that you use to link/coordinate [utility]'s C&S Program activities with the activities of other stakeholders in revising the energy efficiency standards for buildings and appliances.

How well do these procedures work?
What changes could be made to improve these procedures?

What are the major ongoing costs for the C&S Program at [utility] (e.g., staff costs, contractor costs)? [Note: program documentation may be used to answer this question.]

How do costs break down by major program component?

Have certain activities been more costly to provide than expected? If so, why?

What are the most significant challenges that you experience as the Program Manager responsible for administering the C&S Program? (For example: coordinating with other energy efficiency programs? Coordinating with other utilities?)

How have you addressed these challenges?

Do you feel that the level of accountability and oversight that the C&S Program receives from [utility]'s management is less, about the same, or more than for other energy efficiency programs that [utility] administers?

Please rate the overall effectiveness of the C&S Program activities of [utility] on a scale of 1 to 10 (where 10 represents the highest effectiveness and 1 the lowest).

What are the main reasons that you choose that rating?
What do you think could be done to improve the overall effectiveness of [utility]'s C&S Program activities?

Consider now the effectiveness of particular program components or activities. Please provide any impressions that you might have about the effectiveness of the major components of the program?

For example: What program components appear to be most successful?
Why have they been successful?
What program components appear to be less successful?
Why have they been less successful?

Please rate the overall effectiveness of the Statewide C&S Program activities on a scale of 1 to 10 (where 10 represents the highest effectiveness and 1 the lowest)

What are the main reasons that you choose that rating?
What do you think could be done to improve the overall effectiveness of Statewide C&S Program activities?

What changes in the Statewide C&S Program do you think could be made to improve its effectiveness? What changes in [utility]'s C&S Program do you think could be made to improve its effectiveness?

Draft Interview Guide for CEC Staff

How long have you been associated with the process used by the CEC for revising the Title 24 and Title 20 codes?

How does the CEC determine when to develop a new standard or revise a current standard?

Briefly describe the following aspects of the code revision process.

- How is broad representation in the process ensured?
- What efforts are made to have a balance of interests among parties having material business interest in building and appliance codes?
- What outreach efforts are made to bring parties into the process?
- Is there any mechanism for reimbursing parties who could not otherwise participate because of cost?

What are the most time consuming/troublesome tasks in developing revised standards?

Did you have any involvement in getting the utilities' Statewide C&S Program up and running?

- If so, what was your role?

What is your understanding of the main goals and objectives of the Statewide C&S Program?

Please describe the procedures (e.g., workshops, meetings, telephone calls, etc.) that you use to link/coordinate the CEC's activities in revising the energy efficiency standards for buildings and appliances with those of the utilities in their C&S Programs.

- How well do these procedures work?
- What changes could be made to improve these procedures?

How has the work supported through the C&S Program affected the process by which the CEC revises the energy efficiency standards for buildings and appliances?

- In particular, how has C&S Program funding and support affected the type and number of code revisions that are considered.

How do you think the C&S Program's involvement in the code revision process has affected the involvement of other stakeholders?

Please rate the overall effectiveness of Statewide C&S Program activities in improving the code revision process on a scale of 1 to 10 (where 10 is most effective and 1 is not effective at all).

- What are the main reasons that you choose that rating?
- What do you think could be done to improve the program's overall effectiveness?

Although the C&S program is a statewide program, each utility has structured its program so that program components are somewhat different among utilities. (Examples of components include CASE studies, builder education, etc.) Please provide any impressions that you might have about the effectiveness of different components of the program?

- What program components appear to be most successful?
- Why have they been successful?
- What program components appear to be less successful?
- Why have they been less successful?

Do you have any general suggestions for changes and/or improvements to the Statewide C&S Program that you think would help the CEC improve its code revision process?

Interview Guide for Organizational Stakeholders

Briefly describe the membership of your organization and your role in it.

Are any utility personnel active in your organization?

Are any CEC staff members active in your organization?

How long has your organization been involved in the process used by the CEC for revising the Title 24 building code and Title 20 appliance code?

How does your organization arrive at the positions it takes on proposed changes to the buildings or appliance codes?

Is "consensus" required?

If “consensus” is not required, what percentage concurrence is required for action?

How is membership concurrence obtained?

Does your organization sponsor any studies or conduct any research that is provided to CEC for use in the code revision for buildings and appliances?

How does your organization interact with CEC during the process of revising the building and appliance codes?

For example: do CEC staff for the code revision process contact your organization for information during the code revision process?

Do you make presentations at public hearings on proposed changes to standards and codes?

Has your organization's participation in the CEC code revision process changed over the years?

If so, how has the participation changed?

What barriers, if any, do you see to organizations like yours participating in the CEC’s code revision process?

Have such barriers increased or decreased over the past five years?

What suggestions do you have for lowering any barriers to your participation?

What suggestions do you have that might improve the process that the CEC uses for code revisions?

Are you familiar with the utilities’ Statewide C&S Program?

If so, **w**hat is your understanding of the main goals and objectives of the C&S Program?

What do you feel has been the impact of the C&S Program on the code revision process used by the CEC?

Please rate the overall impact of utilities’ C&S Program activities on building and appliance code changes on a scale of 1 to 10 (where 10 is most impact and 1 is no impact).

What are the main reasons that you choose that rating?

Has your organization changed how it participates in the CEC code revision process because of the utilities involvement through the C&S Program?

For example: How has your organization’s budget for participation in the CEC code revision process changed since 1998?

If budget has changed: what has caused this change in the budget?

Does your organization have any procedures that you use to link/coordinate your activities in revising the energy efficiency standards and codes for buildings and appliances with the activities of the utilities in their C&S Programs?

If so, please describe these procedures?

How well do these procedures work?

What changes could be made to improve these procedures?

If you are not currently coordinating with the C&S Programs, would you be interested in doing so?