MA&E Study in Support of Codes & Standards

FINAL REPORT
Volume I: Project Description and Results

PG&E Study ID number: 411

August 31, 2000

Measurement and Evaluation
Customer Energy Efficiency Policy & Evaluation Section
Pacific Gas and Electric Company
San Francisco, California

Market Assessment & Evaluation Study in Support of Codes and Standards

Final Report
Volume I: Project Description and Results

A Joint Study by Pacific Gas & Electric, San Diego Gas & Electric, Southern California Edison, Southern California Gas, and the California Energy Commission

Statewide Project Manager: Mary G. Dimit, PG&E

Project Advisor: William Pennington, CEC

Prepared by
Pacific Consulting Services
1320 Solano Avenue, Suite 203
Albany, CA 94706
510/526-3123

Davis Energy Group
123 C Street
Davis, CA 95616

Eley Associates
142 Minna Street, 2nd Floor
San Francisco, CA 94105

August 31, 2000

ACKNOWLEDGEMENTS

Pacific Consulting Services is grateful for the help of the following people: Mary Dimit, PG&E project manager, for overall direction, support and assistance throughout the project; Bill Pennington of the CEC, for invaluable guidance to resources and thoughtful review of our approach and results; members of the Codes and Standards Statewide Committee, who gave careful review of the recommendations; Ken Gillespie of PG&E who provided information about inclusion of building commissioning in the Massachusetts building code; and members of Davis Energy Group—Mark Berman and Mark Hoeschele, in particular, and Eley Associates—especially Erik Kolderup, who contributed substantially to the study.

TABLE OF CONTENTS

Volume II: Appendices (separate cover)

Volume III: Literature Review (separate cover)

EXECUTIVE SUMMARY

INTRODUCTION AND BACKGROUND

Pacific Gas and Electric Company (PG&E) contracted with the Pacific Consulting Services team to develop recommendations on how to improve the new construction industry's effectiveness in installing energy efficiency products commonly used to demonstrate compliance with California's Title 24 energy efficiency standards. This study was initiated as part of the second phase California Board for Energy Efficiency (CBEE) studies for 1999. It was conducted as a statewide study, involving the four investor-owned California utilities—PG&E, Southern California Edison (SCE), San Diego Gas & Electric (SDG&E), and Southern California Gas (SCG)—and the California Energy Commission (CEC).

In proposing this study, the CBEE, the utilities, and the CEC recognized that energy standards and codes are central to capturing the public policy benefits of energy efficiency programs. Standards provide a means of energy performance measurement, allowing a fair basis for comparison between alternative products and practices. Codes also provide enforceable minimum levels of performance. The combination of standards and codes establishes baselines from which energy efficiency improvements can be evaluated. In California, the Title 24 energy efficiency building standards apply to new residential and nonresidential construction as well as most major building renovation projects.

STUDY PURPOSE

This study was designed to include: 1) characterization and development of ideas on how to improve the construction industry's effectiveness in installing key energy efficiency measures commonly used to demonstrate compliance with Title 24 standards, as well as 2) an assessment of the opportunities to use existing PGC-funded energy efficiency programs to identify and develop potential revisions to Title 24 and support effective infrastructure development and implementation of the Standards. The key aspects of the measure effectiveness and opportunities to use PGC funding assessments are captured in the overall project objectives that guided the study.

Objective 1. This study should assess strategies for improving the construction industry's effectiveness in installing energy efficiency measures commonly used to achieve compliance with

California's Title 24. It should focus particular attention on building commissioning (in the nonresidential sector), diagnostic testing (in the residential sector), third party inspections, and linkages between construction quality and liability insurance concerns.

Objective 2. This study should assess how utilities, either informally or through formal PGC-funded programs, can more effectively influence the standards development and implementation process by promoting consensus for incorporation of industry best practices in the standards. In doing so, this study should document how the codes and standards process can work synergistically with PGC-funded programs to achieve stated program objectives.

The results of the study are intended for use by the investor-owned utilities—including the Codes and Standards Statewide Committee, the CEC, and other interested parties who wish to initiate and/or refine PGC-funded activities to improve the effectiveness of energy efficiency measure installation and influence the development and implementation of the Title 24 energy efficiency building standards.

METHODOLOGY

This study largely consisted of data gathering followed by an assessment and synthesis of those data. No sophisticated quantitative analysis was required or appropriate for meeting the project objectives. The success of the project lay squarely with how thoroughly we examined information about activities related to quality installation of energy efficiency measures and development of building codes and standards, and how well we engaged the attention of key players in this market. To that end, we developed a systemic data collection procedure that allowed us to gather information and then use that information at each stage of the study to determine which areas to probe further, identify additional people to contact, and formulate recommendations to test.

The data collection effort started with an extensive review of the literature during which we also gained insight about key players in the building construction market and issues related to energy efficiency installation effectiveness and codes and standards in that market. The literature review comprises Volume III of this project report. It includes a detailed review of the issues that we identified and a bibliography of about 140 sources that we reviewed.

We followed this with in-depth interviews with 57 industry experts and utility representatives active in this area. The combination of these first two activities allowed us to formulate trial recommendations for improving energy efficiency measure effectiveness that we then tested in a series of five focus groups. We conducted two residential construction industry groups, two nonresidential construction industry groups, and one insurance industry group, covering both Northern California and Southern California to capture potentially different market conditions and concerns. The interviews and focus groups are discussed in Volume I of this report, supplemented with information in the appendices that comprise Volume II of this report.

Ultimately, we synthesized the information gathered from all of these activities, as well as comments from utility representatives—including members of the Statewide Codes and Standards Committee and the CEC—to develop recommendations to improve the effectiveness of energy-efficient installations in residential and nonresidential buildings in California.

By using this multi-stage data-gathering approach, we ensured that we identified knowledgeable market actors and provided opportunities for these experts to share and comment on others' views regarding barriers and opportunities for improvement. Also, we were able to both formulate and test the sensibility and viability of quite a number of trial recommendations.

RECOMMENDATIONS

These recommendations were synthesized from 1) the results of the literature review, 2) the in-depth interviews that we conducted with industry experts, 3) trial recommendations that we tested and revised in the focus groups, and 4) reviewer comments. They therefore reflect the opinions of the people who participated in the focus groups and the comments received from reviewers of those results, including members of the Codes and Standards Statewide Committee and the CEC. A number of these recommendations are already being worked on by the utilities, the CEC and others.

Developing these recommendations in consultation with leading edge market actors with direct experience and insight into the building performance issues that we identified, rather than a random sample of actors, raised two concerns. First, these people are not completely representative of their respective groups. The majority of builders, inspectors, etc. are not yet sensitized to these issues or potential solutions. Using our "experienced" group, we could jump right into developing strategies to improve measure effectiveness and the code process, rather than spending time educating people and then obtaining their first thoughts about it. Second, the recommendations would reflect their biases rather than providing ideas that are truly valuable and viable to the community. We attempted to prevent this from happening by using the focus groups, which each consisted of different market actors, to develop consensus strategies. The recommendations here are only those that reflected collective thinking. Please note that there may be other viable options not identified here.

We recognize that there are challenges, in some cases considerable, to implementing the recommendations. The wording of these recommendations and the caveats noted address these challenges and capture the comments of the study participants and the reviewers. Several challenges noted apply to many of the recommendations in both the residential and nonresidential markets. These include:

- Increased building costs are always problematic to the construction industry. Nevertheless, many improvements in construction effectiveness promise to result in reduced building owning and operating costs, at least after the industry transitions to new practices. The utilities, the CEC, and organizations, such as CBIA, need to consider how to enact recommendations that achieve improved energy efficiency objectives in a manner that mitigates potential increased first costs.

- The recommendations may be more burdensome to smaller and custom builders. Larger builders have a larger base across which to spread the costs of training and testing.

- Procurement of long-term funding for some of the recommendations will be important. While PGC funds are recommended to 'kickstart" some of these actions, they are not expected to remain permanently available.

- A number of the recommendations cannot be implemented solely by the utilities. They will require non-utility proponents to champion them into practice.

Recommendations for Residential Construction

1. Require mechanical drawings as part of design documents for building permits.

The goal of this recommendation is to foster continuity from design through construction. We heard support for this in nearly every in-depth interview as well as in both the residential focus groups. Contractor completion of Manual J and D design for each house plan, when followed, has been shown to be especially helpful in reducing HVAC defects. There is activity underway at several utilities to encourage good design.

Caveats to Recommendation 1: While requiring mechanical drawings is widely expected to improve HVAC and duct performance, it does not guarantee quality workmanship. Designs can be disregarded or altered during construction. Thus, without field verification, this recommendation cannot ensure measure effectiveness.

2. Require certification of HVAC and insulation contractors and installers. Tie the certification to successful completion of training courses. Require an affidavit from contractors documenting satisfactory self-inspection results and performance testing reports as precondition for issuing occupancy permit.

In interviews and focus groups, certification was heralded as an important component of improving HVAC and insulation effectiveness. The importance of including both contractors and the actual installers in the certification was noted so that the certification would be more meaningful. Surprisingly, most participants in the focus groups supported the idea of self-inspection, and were, in general, much more trusting of each other than previous studies have shown.

Caveats to Recommendation 2: Several items clearly need to be addressed of implement this recommendation. One is to determine how certification relates to current contractor licensing. Another is procurement of long-term funding to cover the costs of the certification program. PGC funds may be used to partially or fully offset the cost of setting up the training and certification, but since that funding is not expected to last in perpetuity, other mechanisms need to be explored to sustain the activity. This recommendation will require that utilities and the CEC work with professional/industry associations to develop and perhaps take responsibility for certification.

3. Establish mechanisms to conduct random, third-party inspections for quality control.

Inspections would be conducted by people who are not local building inspectors and would cover a sample of homes constructed by each builder. CBIA strongly supports the concept of independent, third-party inspections and using a sampling approach to control costs. Some large builders said they are already doing this.

Caveats to Recommendation 3: It is clear that before this recommendation can be implemented, quite a number of issues need to be resolved. Questions that were raised by project participants include: To whom will the third-party inspectors report and how will the results be used? How will the sample homes be chosen? At what stage(s) of construction will the homes be inspected? Then there is the issue of cost. PGC funds may be used to establish the third-party inspections, train the inspectors, and initially pay for the inspections. At this time, it is unclear whether this could become a self-sustaining market-based change or whether a long-term funding mechanism will be necessary to ensure the sustainability of this practice.

4. Use PGC funds to conduct contractor and installer training on proper installation, proper testing, and recent changes to Title 24.

Support is widespread for using PGC funds to conduct contractor training on proper installation, testing, and recent changes to Title 24. Discussing concerns about how to effectively reach busy contractors, the focus group participants most favored the idea of on-site demonstrations of proper installation. Also, by going to the job site, one can target the installers, not just the contractors who employ them. Another suggestion was to create a special section on the CEC website that provides a quick overview of Title 24 changes.

Caveats to Recommendation 4: This recommendation is already a work-in-progress. The utilities have a number of training sessions available to members of the building industry—including Title 24 consultants, local building officials, HVAC contractors and installers, architects, mechanical engineers, equipment suppliers, developers, and Realtors. A list of these training sessions is included in Volume II, Appendix E of this report. Despite offering training at alternative locations and times, the utilities find they are not always successful at persuading the intended market actors to attend the training sessions. Conducting training sessions at the construction site may address this barrier.

5. Use PGC funds to augment and train local building inspectors on the "house as a system" approach.

Many of those interviewed felt that the local building inspectors are not up to date on the new energy-efficient technologies, and do not understand the interactive nature of a home's component systems and the implications of the poor performance of any one component on the others. Having inspectors trained at actual homes would be an effective way to deliver training on diagnostics and quality construction results. Comments on this recommendation were all favorable, both during the focus groups and in subsequent review. Reviewers thought that having building inspectors trained on the "house as a system" approach would enhance compliance. Most, but not all, agreed that having more trained inspectors would be beneficial in decreasing potential construction delays that could arise from inspectors being unfamiliar with the methods.

Caveats to Recommendation 5: Barriers go far beyond the need for training and are more related to lack of local government budget resources, low priority of energy efficiency relative to health and safety code requirements, and lack of educational and professional expertise. Implementing this recommendation will require the utilities to enlist the support of and collaborate with several parties. Partnerships with professionals who can provide the training will be necessary. Interactions to gain the support of local building officials will be necessary. Finally, this will likely need a non-utility champion to make it happen.

6. Conduct additional research to quantify potential non-energy benefits of a systems approach to home construction. Quantify the benefits from reduced callbacks and reduced exposure to litigation.

This is currently considered a "hot issue" at insurance industry conferences, suggesting that now would be a favorable time to initiate such a study.

Caveats to Recommendation 6: We need to emphasize that the litigation referred to is rarely, if ever, due to energy efficiency performance failures, and energy standards cannot be used to enforce construction quality. Nonetheless, we are already seeing a convergence of interests here that reinforce the value of conducting energy efficiency measure benefit assessments. The American Architectural Manufacturer's Association (AAMA) has been working with window manufacturers because of leakage litigation problems, offering an opportunity to also discuss improving energy efficiency through better construction and installation of window units. Also, the Building Industry Institute has been successful in associating improved quality in energy-efficient construction with reduced builder exposure to liability. Finally, it should be noted that quantifying non-energy benefits of building energy efficiency improvements in ways that are meaningful and actionable for the insurance industry may be difficult to accomplish.

7. Increase consumer education on energy efficiency by way of a mass media public awareness campaign.

There was quite a bit of debate during data collection efforts regarding the role of consumer demand in driving the marketplace toward higher efficiency and quality construction. By increasing consumer education and creating value for quality construction and energy efficiency, builders and contractors alike believe consumers will begin asking for more efficient homes.

Caveats to Recommendation 7: The utilities already have some energy efficiency consumer awareness programs in place. To help builders see the value of energy efficiency, these programs could be more focused on identifying and educating consumers about a few specific measures that they should look for in a new home.

8. Establish simple, standardized diagnostic testing procedures.

While nearly everyone agreed that diagnostic testing procedures should be required, the dilemma is how to define such procedures. By establishing common protocols in the standards, everyone will have access to information on how to conduct diagnostic testing.

Caveats to Recommendation 8: This has already been accomplished for duct testing. The standard is the Duct Blaster test. This type of standardization needs to be extended to other HVAC components and the building envelope. PGC funds could perhaps be used to facilitate this extension.

9. Simplify Title 24 while raising the standards (i.e., make them more stringent but easier to understand and apply).

Title 24 is considered by many, if not all, as far too complicated and hard to understand. Simplifying the standards would reduce confusion and improve the likelihood of compliance. These same respondents said that more stringent standards should be required, such as offering fewer credits for easy trade-offs; e.g., credits for installing interior window shading. Many complained that contractors and builders opt for the lowest cost credits, even if they doubt their effectiveness, and therefore sacrifice energy efficiency. This recommendation would help rectify this problem.

Caveats to Recommendation 9: There was considerable agreement on this recommendation, despite its potential restrictiveness. In the focus groups, (large) builder representatives said they expect there would be support among builders for simpler requirements even if they are more stringent. CBIA, which might be more widely representative of builder views, supports the mandate that any update to Title 24 must be cost-effective in its entirety when compared with historical practice. To implement this recommendation, it is evident that representatives from many groups will have to grapple with the trade-off between the increased compliance that simplicity would facilitate and the additional costs that increased stringency would likely impose.

10. Offer state tax credit for green and tested, energy-efficient buildings to both builders and consumers.

By offering a state tax credit for “green” (and tested) energy-efficient buildings, market actors are being encouraged to pursue field-verified energy efficiency. Respondents believed that this might be more successful if associated with construction of “green” buildings. By splitting the incentive, so that both owners and builders receive a portion of the tax credit, it would ideally create a symbiotic push-pull approach to market transformation. Obviously, the infrastructure would need to be in place to support the tax credit, as well as governmental buy-in. Everyone who reviewed this recommendation thought it would be helpful for promoting energy efficiency.

Caveats to Recommendation 10: This is clearly a recommendation that utilities cannot implement on their own. It will need a champion within the legislative process.

Recommendations for Nonresidential Construction

Most of the recommendations for the nonresidential market are analogous to the recommendations made for residential construction. There are, however, several differences worth pointing out. First is the recommendation of mandatory testing for nonresidential construction. Second is the no recommendation of third-party inspections. Third is a provision that could prove especially helpful to smaller building owner/developers or potential commissioning agents: an equipment lending library. Finally, there were no recommendations to simplify and increase the stringency of the standards.

1. Require commissioning of the HVAC system and lighting controls with the mechanical engineer of record responsible for the HVAC system and the architect responsible for the lighting.

The systems most at risk for construction defects in new nonresidential buildings are the HVAC and the lighting controls systems. While architects and builders alike might be reluctant to commission the whole building due to cost and time constraints, these two systems in particular should be addressed. Since the mechanical engineer is responsible for designing the HVAC system, it seems most appropriate assign responsibility to this party for ensuring that this system operates as designed. Architects or lighting designers should see that lighting and the control systems are installed and function as planned. In particular, since occupants can and do override controls when the lights do not perform as needed, the lighting designer needs to ensure that the controls are appropriately installed and calibrated. There is precedent for this recommendation in similar requirements, that were put into effect in Massachusetts in January 2000.

Caveats to Recommendation 1: The biggest problem with implementation of this recommendation may be how to overcome the cost burden that this will impose on builders. Full building commissioning costs can be 10-20% of the construction cost of a building. Also, a commissioning infrastructure needs to be developed in California, including training for lighting designers and mechanical engineers on commissioning procedures. Public electricity charge funding is being used in the Pacific Northwest, New York, and other northeast states to develop a commissioning infrastructure in those parts of the country. PGC funds could be used to develop this infrastructure in California.

2. Use PGC funds to offset costs of commissioning.

Building owners and developers often see commissioning as a discretionary cost that could lead to construction of the building going over the budget and eating up profits. Commissioning can be one of the first things to go when construction budgets get over-extended. By using PGC funds to offset the costs of commissioning, the likelihood of having commissioning cut from the plans could be alleviated.

Caveats to Recommendation 2: It is not anticipated that PGC funds will be available to cover the entire cost of commissioning or that they will be available indefinitely. Since building commissioning includes drafting written plans, conducting testing, and fixing mistakes, its unclear whether PGC funds should be applied to all or only some components of commissioning.

3. Design simple and uniform testing protocols.

Commissioning implies many things to many people. Having simple and uniform testing protocols would alleviate confusion regarding what constitutes the commissioning process. Some headway has been made in addressing this: ASHRAE has a committee on testing protocols. PG&E is also developing testing guidelines.

Caveats to Recommendation 3: This recommendation will require collaboration between commissioning experts developing the guidelines and the professionals that will be trained to use them. Furthermore, while utilities can and are encouraging uniform protocols, they cannot impose them.

4. Use PGC funding to establish a standardized certification process to train and certify commissioning agents.

This recommendation directly addresses several of the commonly cited barriers to building commissioning: cost, lack of awareness of pervasive equipment performance problems, and lack of knowledge on how to perform testing. By requiring training and certification, professional commissioning agents would be able to see the benefits that commissioning offers, understand commissioning practices, and demonstrate their competency in applying the procedures.

Caveats to Recommendation 4: We realize the CEC does not currently have the authority to "certify" commissioning agents. Teaming with or encouraging professional organizations such as ASHRAE or the Building Commissioning Association to certify them was seen by project participants as viable and highly recommended. Developing and sustaining this infrastructure component will likely require continued funding over the medium to long term.

5. Use PGC funds to create a library of testing equipment for builders and their commissioning agents to borrow.

This recommendation stems from feedback we received about the lack of ownership of equipment for testing building systems. Such equipment is often too expensive for a building owner/developer or potential commissioning agent to acquire for infrequent use. Activity is already underway on this recommendation. The Pacific Energy Center has started an equipment lending library. Increased access to testing equipment is part of the infrastructure needed for some of the other recommendations to be effective.

Caveats to Recommendation 5: The issues that need to be addressed for this recommendation include identifying which equipment to make available, and establishing the locations from which the equipment might be obtained.

6. Use PGC funds to conduct additional studies on costs and benefits of building commissioning, including a quantitative cost-benefit analysis of commissioning relative to energy and non-energy benefits, such as improved air quality and better work environment resulting in higher productivity.

Suggestions for additional studies of the nonresidential sector primarily focus on generating and communicating findings from successful building commissioning demonstration projects. Many builders said that having such studies available would help them sell commissioning to building owners and justify allocating part of the project's budget to commissioning.

Caveats to Recommendation 6: This recommendation is similar to that made for residential construction and faces the same challenges.

7. Offer state tax credits to builders and building owners for commissioning energy-efficient and "green" buildings.

As in the residential market, by offering a state tax credit for "green" (and tested) energy-efficient buildings, market actors are being encouraged to pursue field-verified energy efficiency.

Caveats to Recommendation 7: This recommendation is similar to that made for residential construction and faces the same implementation challenges.

Recommendations for Future Research

Implementation of some of the recommendations made here will require or would greatly benefit from additional research. These items include:

- Conduct studies that assess and document the energy as well as non-energy benefits of diagnostic testing and/or building commissioning to market actors, including insurers, builders, and owners/buyers. These should be actuarial quality studies that would afford insurers confidence to reduce builders' premiums for performance tested and commissioned buildings.
- Actively foster partnerships with professional associations in the construction industry to facilitate development and implementation of training and certification for diagnostic testing and building commissioning.
- Determine exactly how requirements of Title 24 (current and proposed) overlap with activities that comprise building commissioning. This may involve revisiting and/or revising the working definition of building commissioning for best use in California.
- Track how building commissioning in Massachusetts is working to gauge the likely practicability and benefit of the first nonresidential recommendation above.
- Since there is still some controversy regarding the use of third-party inspections in residential construction, conduct a study to investigate their need/acceptance and develop practical strategies for using them.
- The residential and nonresidential recommendations above are somewhat general. Further investigation needs to be made into which submarkets of the construction industry will be the best hosts for these recommendations. Utility/PGC-funded programs should be directed at implementing the recommendations in these markets first.

1 INTRODUCTION

A. Introduction and Background

Pacific Gas and Electric Company (PG&E) contracted with the Pacific Consulting Services team to characterize the new construction market relative to the construction industry's effectiveness in installing energy efficiency products commonly used to demonstrate compliance with California's Title 24 energy efficiency standards. This study was initiated as part of the second phase California Board for Energy Efficiency (CBEE) studies for 1999. It was conducted as a statewide study, involving the four investor-owned California utilities (PG&E, Southern California Edison (SCE), San Diego Gas & Electric (SDG&E), and Southern California Gas (SCG)) and the California Energy Commission (CEC).

In proposing this study, the utilities and the CEC recognized that energy standards and codes are central to capturing the public policy benefits of energy efficiency programs. Standards provide a means of energy performance measurement, allowing a fair basis for comparison between alternative products and practices. Codes also provide enforceable minimum levels of performance. The combination of standards and codes establishes baselines from which energy efficiency improvements can be evaluated. In California, the Title 24 energy efficiency building standards apply to new residential and nonresidential construction as well as most major building renovation projects. However, market transformation gains in design practices, building shells, or appliances are not permanently captured until they are reflected in improvements to standards, codes, and building energy budgets.

B. Research Objectives

This study was designed to include: a market characterization of the construction industry's effectiveness in installing key energy efficiency measures commonly used to demonstrate compliance with California's Title 24 energy efficiency standards, and an assessment of the opportunities to use existing Public Goods Charge (PGC)-funded energy efficiency programs to identify and develop potential revisions to California's Title 24 energy efficiency standards and to support effective infrastructure development and implementation of the standards. This study focused on assessing:

- the barriers to achieving quality in the construction and installation of energy efficiency features,
- the barriers to using diagnostic testing (residential construction) and building commissioning (nonresidential construction) as means of ensuring that building energy performance expected to result from compliance with Title 24 is actually achieved, and
- the potential for using third parties as special inspectors to increase construction quality and ensure building energy performance.

Discussion at the kick-off meeting and informal conversations with PG&E and the CEC provided the opportunity to refine the objectives that ultimately guided the study.

- **Objective 1** This study should assess strategies for improving the construction industry's effectiveness in installing energy efficiency measures commonly used to achieve compliance with California's Title 24. It should focus particular attention on building commissioning (in the nonresidential sector), diagnostic testing (in the residential sector), third party inspections, and linkages between construction quality and insurance liability concerns.
- **Objective 2** This study should assess how utilities, either informally or through formal PGC-funded programs, can more effectively influence the standards development and implementation process by promoting consensus for incorporation of industry best practices in the standards. In doing so, this study should document how the codes and standards process can work synergistically with PGC-funded programs to achieve stated program objectives.

i. Objective 1: Improve Effectiveness of Measure Installation

The approved research plan called for meeting the first objective by performing the following tasks:

1. Develop a list of residential and nonresidential measures that are either required for standards compliance using the prescriptive approach or are commonly relied on to achieve compliance using the performance approach.

2. Evaluate the effectiveness with which these measures are currently installed, focusing on actual building performance rather than paper compliance. For subsequent steps, focus on measures for which there is evidence of performance problems.

3. Identify the market actors with important decision making roles in the installation of measures with performance problems.

4. Assess the incentives and disincentives each market actor has to make decisions that lead to effective installation and function of targeted measures versus circumventing the intent of the standards.

5. Summarize the barriers to effective installation and function of targeted measures.

6. Assess the opportunities to use building commissioning, diagnostic testing and third-party inspections, and linkages between construction quality and both liability insurance concerns and financing considerations as strategies to improve the effectiveness of measure installation. Draw lessons from other energy-efficient building programs and pay particular attention to the compatibility between the proposed strategies and the identified interests of various stakeholders.

7. For those strategies considered viable, develop recommendations for how they might be promoted, either through PGC-funded programs or through modifications to the standards development and implementation process.

ii. Objective 2: Assess Utility Opportunities to Influence Standards Process

The approved research plan called for meeting the first objective by performing the following tasks:

1. Describe the process by which California's energy standards are developed, modified, and implemented.

2. Assess opportunities for using the standards process as a tool for PGC-funded programs to meet their program objectives. Assess whether utility PGC program planning processes should be modified to establish closer links between the standards process and PGC program objectives.

3. Review utility involvement in the standards process and explore factors contributing to the success or failure of those interventions.

4. Develop recommendations for ways utilities and PGC-funded programs can effectively influence the standards process.

C. Report Organization

The remainder of this report discusses the research approach, study findings, and our recommendations for future activities and research. This volume of the report is supplemented by two additional volumes. Volume II contains five appendices: lists of industry experts and utility staff we interviewed and/or who participated in the focus groups, data collection instruments, summaries of interviews that we used to develop the interim and final recommendations presented in this report, and listings of utility-sponsored activities in 2000 that are related to Codes and Standards. Volume III contains the results of the literature review that we conducted at the outset of the project that helped shape the issues we examined.

2 METHODOLOGY

A. Overview

This study largely consisted of data gathering followed by an assessment and synthesis of those data. No sophisticated quantitative analysis was required or appropriate for meeting the project objectives. The success of the project lay squarely with how thoroughly we examined information about past and ongoing activities related to quality installation of energy efficiency measures and development of building codes and standards and engaged the attention of key players in this market. To that end, we developed a systemic data collection procedure that allowed us to gather information and then use that information at each stage to determine which areas to probe further, identify additional people to contact, and formulate recommendations to ultimately test.

The data collection effort started with an extensive review of the literature during which we gained insight about key players in the building construction market and issues related to energy efficiency installation effectiveness and codes and standards in that market. We followed this with a number of in-depth interviews with identified industry experts and utility representatives active in this area. The combination of these two activities allowed us to formulate straw-man recommendations for improving energy efficiency measure effectiveness that we then tested in a series of focus groups. These focus groups consisted of residential and nonresidential market actors and were conducted across the state to capture a diversity of views. Ultimately, we synthesized the information gathered from all of these activities, as well as comments from utility representatives—including members of the Statewide Codes and Standards Committee-to develop recommendations to improve the effectiveness of energy-efficient installations in residential and nonresidential buildings in California.

Some of the experts we interviewed had contributed to the body of literature we reviewed. And most of the focus group participants had been among the people we had interviewed. By using this multi-stage data-gathering approach, we ensured that we identified knowledgeable market actors and provided opportunities for these experts to share and comment on others' views regarding barriers and opportunities for improvement. Also, we were able to both formulate and test the sensibility and viability of quite a number of trial recommendations for recipients of this report.

The remainder of this section describes what we did in performing each of these activities.

B. Literature Review

To maximize the effectiveness of our data collection and analysis efforts, we wanted to avoid duplicating previous research efforts and make full use of published literature and data sources. Thus we conducted an extensive review of literature and other secondary sources that provided inputs into other key tasks. The review was targeted at literature and other data sources that contained information most critical to the study. Types of literature we reviewed included:

- **California Energy Commission Documents and Data.** We started our review with the Title 24 Standards and associated manuals, newsletters, and other tools the CEC has developed to promote code compliance. In addition, we reviewed several studies the CEC has conducted or sponsored that investigate Title 24 compliance.

- **Utility Documents.** We focused on utility PGC-funded programs since 1997, and our review looked at program design documents and evaluation results since that year.

- **Other Energy Program Documents.** Organizations outside of California have quite a bit of experience in building commissioning, diagnostic testing, energy-efficient building programs, energy code development, energy-efficient financing, and insurance issues. We explored information from a number of organizations.

- **Conference Proceedings.** We reviewed recent proceedings from conferences organized around building commissioning and energy code issues, including the proceedings for the 7th National Conference on Building Commissioning and Affordable Comfort conferences.

- **Other Consultant Studies.** We reviewed a number of studies that specifically investigate the current issues surrounding Title 24 and building commission protocols, such as Portland Energy Conservation, Inc.'s *National Strategy for Building Commissioning* (for the US Department of Energy), National Institute for Building Science reports on total building commissioning guidelines development, ConSol/LBNL duct and building envelope protocol projects, LBNL's residential building commissioning project, and various field studies on duct leakage and the need for whole house diagnostics.

- **Industry Periodicals.** Publications from building industry and commissioning associations were looked at to gain their insights into guidelines for successful commissioning and Title 24 compliance strategies. Examples include *Architectural Record* (published by AIA), *Building Operating Management*, *Home Energy* and *Energy Design Update*.

- **State Building and Energy Codes**. We also looked at other codes from states likely to be progressive in their code development and enforcement.

- **Related Studies.** Finally, we researched numerous available reports that address the linkage between building performance and issues such as occupant productivity and health, liability exposure, and financing.

This extensive literature review is available under separate cover as part of the documentation for this project.

C. In-depth Interviews

Our primary data collection efforts were initiated with a series of in-depth interviews with industry experts and utility staff. We compiled a database of more than 110 relevant industry contacts and completed 57 in-depth interviews. Most interviews were conducted by phone, however, whenever time and budget allowed, we were able to conduct in-person interviews (e.g., utility and CEC staff).

These interviews were a critical mechanism for assembling important contextual information, scoping out key issues related to the study research questions, isolating areas of agreement and disagreement, and helping to formulate recommendations we would later test in the focus groups. The interviews were exploratory in nature. For each interview we had a battery of issues we wanted to probe. We organized these issues and the interviews in nine modules. The interview guides are included as Appendix B. The modules are:

Module A. Construction practices in building quality and call backs

Module B. Diagnostic testing and performance testing for residential buildings

Module C. Building commissioning and performance testing for nonresidential buildings

Module D. Energy efficiency financing (energy-efficient mortgages, performance contracting, building appraisals, etc.)

Module E. Insurance/liability issues related to construction quality

Module F. Energy-efficient building and “green” building initiatives

Module G. Title 24 revision process

Module H. Using Title 24 to promote energy efficiency program objectives

Module I. Utility involvement in the Title 24 process

D. Focus Groups

Complementing our in-depth interviews, we used focus groups to explore potential recommendations that resulted from the interviews. There were three outstanding areas for which further exploration was necessary and recommendations were developed: residential diagnostic testing, nonresidential building commissioning, and insurance liability issues. We held five groups total, representing both Northern and Southern California.[1]

Focus group participant names were largely assembled from referrals of experts we had interviewed earlier in the project. Candidates were selected who seemed best suited to discuss the issues we wanted to address in each group. Locations were similarly chosen. We held the groups in places that could be most easily reached by the people we wanted to attend. For example, the insurance focus group was held in San Diego because of the high level of litigation concern indicated in that area. We included market actors in each group who represented different segments of the industry, gaining a multitude of perspectives. These included builders, contractors, architects/designers, engineers, inspectors and program staff. The focus groups were sprinkled with industry experts we had previously interviewed individually. The list of focus group participants is included in Appendix A of this report. Copies of the focus group discussion guides can be found in the Appendix C.

[1] We had initially scheduled six focus groups, however one of the Northern California focus groups was cancelled due to participant cancellations. Follow-up calls were placed to elicit opinions of those intended participants.

E. Analysis

The bulk of the effort in this project was directed toward qualitative data collection strategies—in-depth interviews and focus groups. The analysis associated with these efforts focused on summarizing results and reviewing them for patterns or trends. We also compared primary data collection results with findings from our review of secondary sources and documented experiences in other regions. Summaries of these findings are included as Appendix D.

Our analysis of interview and focus group results culminated in the formulation of findings and recommendations for future PGC-funded intervention strategies to influence the standards process. Recommendations that emerged from our analysis were tested for their ability to contribute to sustainable market effects. In keeping with the CEC's desire to more closely align the standards process with market forces, we conducted this test by subjecting each potential recommendation to the following series of questions:

- Would the recommended intervention lead to changes in standard practice in the construction industry?
- Would the recommended intervention produce steady growth in the market share of energy-efficient building designs and practices?
- Are construction market actors requesting or demanding this intervention?
- Would the recommended intervention reduce or remove risks that construction market actors experience (e.g., customer dissatisfaction, callbacks, and liability)?
- Would the recommended intervention reduce or remove split incentives that construction market actors experience?
- Would the recommended intervention "level the playing field," making it more possible for quality, energy-efficient construction to compete with lower-quality construction?

3 FINDINGS

A. Status of Measure Installation Effectiveness

i. Key Measures Reviewed

From our literature review, we identified those residential and nonresidential measures that are either required for Title 24 standards compliance using the prescriptive approach or are commonly relied on to achieve compliance using the performance approach. These are noted in Table 1.

Table 1. Energy Efficiency Measures Typically Used for Title 24 Standards Compliance

	Nonresidential	Residential
Lighting	Lighting power density Occupancy sensor control Other controls	Kitchen lighting Bathroom lighting
HVAC	Equipment efficiency Equipment part load performance Variable speed fan control Variable speed pump control Economizer Fan system efficiency Equipment sizing Zone control Supply air temperature control	Equipment efficiency Duct design and airflow Duct insulation Duct sealing Fireplace outdoor air source Installation (refrigerant charge, airflow)
Envelope	High performance windows	Envelope sealing and air barrier High performance windows Interior window shades Insulation
Water Heating		Water heater efficiency Pipe insulation

This list of measures served as the basis for our review of measure installation effectiveness. Note that this table does not represent a comprehensive list of all technologies covered by the standards nor does it cover systems not within the scope of the standards (e.g., process systems, elevators, etc.).

For the purposes of this study, a measure is effective if it achieves the energy savings according to the requirements of the standard and/or the system design intent. For example, if a variable speed fan actually slows down as much as it should when air flow drops, then the measure is effective. If, however, due to problems such as improper duct pressure sensor installation, the fan speed does not drop as far as optimal, then the measure is not completely effective. Therefore, a reasonable measure of effectiveness is the fraction of potential savings actually achieved.

Verification of some measures used to achieve compliance can be visually inspected, such as whether or not a required device has been installed. Other measures cannot be qualitatively verified and require diagnostic testing. Examples of quantitative performance testing include measuring whether indoor coil air flow exceeds 350 cfm/ton and if duck leakage is less than 6% of system fan flow.

In order to determine the current effectiveness of the measures and identify which might be worth focusing on in revising the standards and/or in PGC -funded programs, we addressed the following questions by consulting the literature and interviewing industry experts:

- What types of performance problems occur for each measure?
- What are the causes of the problems? Are they related to specification, installation, operation or maintenance? Who is responsible?
- What is the frequency of these performance problems in the state?
- What is the effect of energy standards on measure specification, installation, operation or maintenance?
- Which problems can be addressed through commissioning, third party inspection or diagnostic testing?
- What role might energy standards play in improving measure performance?
- Are other non-energy standards interventions likely to be effective?

a. Residential Measures with Noteworthy Performance Issues

In the residential sector, we found abundant evidence of building performance issues associated with HVAC system design and installation. Building envelopes are also prone to numerous construction defects, although the energy efficiency implications may not be substantial, at least in

California. HVAC and envelope issues are discussed in more detail below. Residential lighting systems offer numerous opportunities for improved energy efficiency through more stringent technology requirements but do not appear to be particularly prone to construction defects.

Residential HVAC Issues

There are many factors that degrade HVAC system operating efficiency below nominal manufacturer-tested equipment performance. According to Neal (1998), four key factors affect performance: incorrect refrigerant charge, inadequate system airflow, duct leakage, and system oversizing.

- Incorrect refrigerant charge has been identified as a problem in over 70% of installations nationally (Neme, Proctor, and Nadel 1999). Correct refrigerant charge for installed systems requires improved HVAC contractor training and attention to detail in the final system tune-up process.

- Inadequate airflow over the indoor coil, which is typically due to reliance on rule-of-thumb duct sizing procedures, results in undersized and overly restrictive duct systems. Industry experts identified the need for mechanical system design as part of the overall house plan as a primary solution to this problem. The lack of system design often constrains the HVAC contractor to sub-optimal solutions for routing the duct system through the existing framing. The consequences include undersized ducts to get through framing pinch points, reliance on building cavities in lieu of return air-supply ducts, and sharp bends in the ducts, which increase air turbulence and are vulnerable to leaks.

- Duct leakage affects system performance in several ways. Return leakage causes unconditioned attic air to be pulled through the air handler unit, resulting in an increased cooling load on the evaporator coil. Supply-side leaks to unconditioned space reduce effective system capacity. A 4-ton cooling system with 11% supply leakage is effectively operating as a 3 1/2-ton system. Duct blaster tests have been developed to diagnose leaky ducts. For maximum utility, these tests should be conducted at the time ducts are installed while the contractor can still access the ducts to fix any leaks.

- The practice of oversizing cooling equipment has been projected to be as high as 47% over Manual J[2] prescribed sizing (Neme, Proctor, and Nadel 1999). Oversizing increases cooling

[2] Air Conditioning Contractors of America. 1986. *Residential Load Calculation—Manual J.* Air Conditioning Contractors of America

energy use and peak demand and requires the homeowner to pay for additional capacity that is not required. From the contractor perspective, oversizing of air conditioning systems has been the easiest way to minimize homeowner comfort complaints, which in reality are due to a myriad of problems including shortcomings in duct design, excessive duct leakage, inadequate airflow, and improper refrigerant charge. A comprehensive strategy of mechanical system design, duct testing and inspections, and HVAC system tune-up can reduce the impetus to oversize cooling systems.

Residential Envelope Issues

Much of California's climate is sufficiently mild that imperfections in the building envelope do not have catastrophic comfort or energy implications. Nevertheless, improperly constructed building envelopes appear to be common. A comprehensive builder training program completed during 1995-1998 found nearly a third of the houses tested had under-insulated ceilings (or other significant problems) and nearly half of the houses had walls with inadequate insulation, significant insulation compression, or other problems (BII and Consol 1998). The most viable solutions for improving the quality of insulation installation appear to be more regular training of installers and more routine inspections of insulation installation. Training efforts in California are hampered by widespread reliance on unskilled immigrant labor. Inspections are complicated by the short window of opportunity to inspect the insulation before it is covered over with wall sheathing.

While envelope issues may be less important than HVAC issues from an energy efficiency perspective (at least in California), it tops the list of risk management concerns. According to industry experts, residential building envelope problems associated with water infiltration are the most common sources of occupant discomfort and litigation. Water often infiltrates from below grade due to problems with the foundation. Water infiltration can also occur due to improper construction techniques in the building envelope. It is reportedly common to find double-glazed windows with bad seals in older homes. Poor roof and wall waterproofing, small roof overhangs, roof failures, and inadequate caulking and flashing all contribute to water infiltration. Moisture problems can also be traced to improperly operating HVAC systems that generate negative air pressure in the house, which can cause moisture to be drawn in and cause rot and deterioration of the insulation.

Based on our literature review of measure installation effectiveness, we concluded that quite a few HVAC and building envelope measures deserve further scrutiny as candidates for significant performance improvements and several others do not, either because there are no significant performance issues or because the identified performance issues do not translate into significant energy impacts. These are summarized in Table 2.

Table 2. Assessment of Residential Measure Effectiveness

	Performance improvements worth pursuing	Insignificant performance issues or effects
Lighting	Bathroom lighting	Kitchen lighting
HVAC	Equipment efficiency	Fireplace outdoor air source
	Duct design and airflow	
	Duct insulation	
	Duct sealing	
	Installation (refrigerant charge, airflow)	
Envelope	Envelope sealing and air barrier	Interior window shades
	High performance windows	
	Insulation	
Water Heating	Water heater efficiency	
	Pipe insulation	

b. Nonresidential Measures with Noteworthy Performance Issues

Nonresidential HVAC Issues

Many of the HVAC issues described for the residential sector also apply to the nonresidential sector. In particular, equipment sizing and duct sizing, layout, and exposure were all described as problems across the board.

For chilled water plants, problems are associated with temperature controls on the condenser water, variable speed pump controls, and component interactions. For air distribution systems, problems are associated with variable speed fan controls and zone temperature controls.

Several performance issues were raised with respect to packaged air conditioners. Informants pointed out that these systems do not perform efficiently under part-load conditions. Cycling on and off is not an efficient operating mode and energy standards do not require economizers for these systems. There are also performance issues with the automatic scheduling and shutoff controls for packaged units. Thermostats often control both the compressor and the fan. When the cooling set point has been reached, both systems shut off at the same time, leaving the building with no ventilation system.

Nonresidential Lighting Issues

Occupancy sensor controls, daylighting controls, and other lighting controls are the most frequently cited sources of lighting performance problems in the nonresidential sector. "The number of occupancy sensors being installed has decreased significantly from 1994 [to 1998]. Occupancy sensors have become somewhat unpopular because of their potential to turn off lights while the space is occupied. In the field we found a great majority of people removing and or over-riding the sensor due to poor functionality." (RLW Analytics 1999). Calibration issues are the most common problem. Users get disgusted and override the systems. It is very uncommon to find a working system that has not been tampered with.

Based on our literature review of measure installation effectiveness, we concluded that several measures deserve further scrutiny as candidates for significant performance improvements and a few others do not, either because there are no significant performance issues or the identified performance issues do not translate into significant energy impacts. These are summarized in Table 3.

Table 3. Assessment on Nonresidential Measure Effectiveness

	Performance improvements worth pursuing	Insignificant performance issues or effects
Lighting	Occupancy sensor control	Lighting power density
	Other lighting controls	
HVAC	Equipment part load performance	Equipment efficiency
	Variable speed fan control	
	Variable speed pump control	
	Economizer	
	Fan system efficiency	
	Equipment sizing	
	Zone control	
	Supply air temperature control	
Envelope		High performance windows

ii. Roles and Attitudes of Key Market Actors in Measure Effectiveness

a. Residential Owners and Home Buyers

The roles and attitudes of homeowners and buyers are well described in Barakat and Chamberlin (1997). According to this study, home purchases involve purchases of a package of desirable housing characteristics, including location, number of bedrooms and bathrooms, square footage, lot size, style, energy efficiency, etc.

In principle, homeowners have multiple incentives to purchase energy-efficient homes, including lower energy bills, increased comfort, and greater control of the indoor environment. However, they also face a number of barriers to purchasing energy-efficient homes. An important barrier is lack of information. Many home owners and buyers lack even basic information about the existence of energy-efficient measures. They also lack the information and technical expertise to weigh trade-offs in long-term costs and benefits, assess risks, gauge the credibility of energy efficiency claims, etc. Another serious barrier is the inseparability of home features. Simply put, energy efficiency may not be packaged together with other home features that rank higher on the buyer's list of purchase criteria.

b. Residential Home Builders

According to RER (1999), production builders are typically large corporations with internal departments and managers who handle a variety of functions including subdivision design and planning, home design, construction, marketing, and sales.

According to Barakat and Chamberlin (1997), home builders (including general contractors and developers) are motivated primarily by economic decision criteria. Their business priorities focus on minimizing construction costs, maximizing home sale values, minimizing construction project time, and minimizing performance problems for which they may be liable after the sale. The same study developed quantitative estimates of the importance builders place on various attributes that contribute to a home's marketability. They found that "[a]s a group, builders perceived location to be the most important criterion, followed by floor plan, sales price, square footage, style, and finally, energy efficiency." Builders' perceptions appear to be generally consistent with study findings regarding homeowners. Cost was repeatedly mentioned, as either a key driver or one of the key drivers for builder decisions, in the interviews we conducted during this project. Costs stemming from performance testing itself and from delays associated with inspections were cited as barriers to increased used of diagnostic testing.

Builders face several barriers to incorporating energy efficiency into their products. For example, builders do not directly benefit from the bill reductions that result from adopting energy efficiency. Builders are somewhat limited in their ability to analyze the trade-offs among alternative energy efficiency measures. This stems from their reliance on Title 24 consultants, who report energy impacts only as achieving or not achieving code compliance. Finally, builders are limited in their ability to specify energy efficiency to bidding contractors.

c. Residential Designers

Production builders develop design concepts internally, typically by a team that includes designers, architects, marketing and sales personnel, and senior management (RER, 1999). Factors that go into the design decisions include target buyer demographics and home features known to be popular among the target group. Characteristics such as square footage and number of rooms are designated and passed on to an in-house or contracted architect, who then prepares floor plans and building elevations. Title 24 compliance documents are prepared by a contracted Title 24 consultant, who recommends any needed design changes to the architect.

d. Residential Contractors

According to Barakat and Chamberlin (1997), contractors are motivated by the need to succeed in competitive bidding processes. Builders evaluate bids on three criteria: cost, ability to meet the construction schedule, and the ability to work without causing the builder undue hassle (e.g., call backs). Thus contractors have an incentive to adopt changes in construction practices that reduce their costs, streamline the construction process, and improve their work product.

HVAC contractors are responsible for determining the specific HVAC equipment and insulated ductwork that will meet the bid specifications. Selection of energy-efficient equipment tends to increase project costs. HVAC contractors are also responsible for determining ductwork sizing, register placement and size, and how the system is balanced. Their decisions are often limited by the need to install ductwork in whatever space is left by the builders, resulting in undersized ducts and numerous corners. HVAC contractors do not generally understand air flows.

Insulation contractors are responsible for determining the specific insulation that will meet the bid specifications. Their decisions are often limited by prior construction decisions. For example, fiberglass batt insulation beyond R-15 typically requires 2"x6" framing instead of 2"x4".

e. Secondary Market Actors in the Residential Sector

According to Barakat and Chamberlin (1997), Realtors play important roles in the home purchase process because "[t]hey are often homeowners' only source of information regarding the characteristics of the homes they are considering and the value of those characteristics. They also often control the sample of homes from which the homeowner chooses to purchase." The report cites Realtors' motivations being to enhance their sales commissions, minimize the time it takes to sell a home, and protect their business reputations. Sales commissions are tied to sale prices and sales volume.

The same study also cites mortgage lenders as important sources of influence. Lenders control the amount of money a homeowner can borrow. Unless the lender understands the connection between energy efficiency and the buyer's ability to make mortgage payments, the buyer may have to make trade-offs between energy efficiency and other factors that drive sales price (e.g., size and location). Lender motivations focus on avoiding risk, maintaining the ability to resell mortgages, and earning commissions through up-front points and fees, which generally are tied to mortgage value. As of 1997 there was only a weak secondary market for energy efficiency mortgages in California, consisting of a FHA program and the lenders Country Wide and Norwest.

f. Nonresidential Building Owners

According to RLW Analytics (1999), owners originate the project but may or may not be the ultimate users of the building. Because owners provide the financing for the work, they have responsibility for final approval of construction details (including any energy efficiency options) and project budgets. The study research findings support the general conclusions that building owner priorities focus on minimizing construction costs, maximizing the value of the finished building, minimizing construction project time, and minimizing performance problems for which they may be liable after project completion.

g. Nonresidential Designers

According to TecMRKT Works (1998), the role of architects and other design professionals in the nonresidential sector depends on the decision-making model adopted. The report describes three such models: (1) a traditional architect-driven plan/design/build model; (2) the design/build model; and (3) the collaborative model.

In the traditional architect-driven plan/design/build model, design precedes construction. The owner engages an architect, usually through a solicitation or competition, who then develops the schematic and manages development of detailed plans and specifications. Design specialists (typically mechanical, structural, and electrical engineers) are often involved in developing the detailed designs and specifications for the HVAC systems, electrical systems, safety and security systems, etc. With drawings in hand, the owner then solicits bids from contractors to construct the building. In principle, this model makes the owner, architect, and supporting designers the key decision makers in the design process and provides for fully integrated design solutions. In practice, full integration does not always occur.

Design/build models offer the advantage of speed. Design and construction are completed on parallel tracks. This model gives the general contractor an important role in developing design solutions. As a consequence, design tends to be formula driven and the level of analysis and integration may not be very high.

The collaborative model has been developed to address integration and quality issues. In this model, the owner hires an interdisciplinary team of architects, design consultants, and contractors. This approach stresses collaboration and coordination to achieve an optimal combination of cost, quality, function, scope, and time to meet the clients' needs. TecMRKT Works (1998) notes that the commissioning literature discusses the need for integration but does not address how such integration should occur. The report suggests that the collaborative model addresses the need for greater integration in the design/construction process.

h. General Contractors

As previously indicated, the role of the general contractor depends on the construction model the owner adopts for the project (TecMRKT Works, 1998). Under the plan/design/build model, the contractor has little design responsibility but is exclusively responsible for carrying out the design in the construction phase. In the design/build model, the contractor, the design and construction process occur on parallel tracks. Many decisions that the architect's design team would make in the plan/design/build model are made in the course of construction by the contractor in the design/build model. In the collaborative model, design issues are fully resolved before construction starts but the contractor has a role in the design process, just as the architects and designers have a role in the construction phase.

B. OPPORTUNITIES TO IMPROVE MEASURE INSTALLATION EFFECTIVENESS

In the early stages of this project, several interventions were identified as possible candidates for improving the construction industry's effectiveness in installing targeted energy efficiency measures. During the literature and industry expert interviews we conducted, we probed these and identified other candidates to help formulate a set of intervention recommendations we could make as the final product of this study. These candidate strategies were:

- Diagnostic testing and third-party inspections (in the residential sector)
- Building commissioning (in the nonresidential sector)
- Linkages between construction quality and liability insurance concerns
- Linkages between construction quality and financing considerations
- Linkages between construction quality and other energy-efficient building initiatives

In this section, we discuss our findings about the candidate opportunities, barriers to their implementation, possible solutions to these obstacles, and, ultimately, which ones seemed worth presenting and evaluating at the focus groups.

i. Diagnostic Testing and Third Party Inspections

For the purposes of this project, the opportunity to improve measure installation effectiveness through diagnostic testing is focused on insulation installation and HVAC design and installation. For insulation installation and other envelope sealing steps, industry experts have advocated expanded training for the installers and a quality control mechanism capable of intervening before any problems are covered over and hidden. For HVAC systems, industry experts have advocated adoption of a systems approach to design and construction, which includes a mechanical design of the HVAC and ducts as part of the initial blueprints; making sure designs are followed; and performance testing of the ducts and HVAC system. For convenience in the following discussion, we refer to a comprehensive system of design, inspection, and performance testing, covering both HVAC systems and envelope construction, as "diagnostic testing."

There is some difference of opinion within the industry whether efforts to promote performance testing should focus on standard production homes or on large custom homes. On the one hand, one can argue that the potential for large energy savings and the complexity of large custom home construction makes these projects the preferred candidates for testing. On the other hand, the sheer volume of production houses amplifies the energy impacts of even minor construction defects, if repeated on a broad scale.

a. Trends in Diagnostic Testing and Third Party Inspections

The most recent changes to Title 24, adopted in July of 1999, incorporate duct design and testing and building envelope sealing as optional compliance approaches. The full impacts of those changes have yet to be seen. Builders pulled large numbers of permits prior to the adoption date. Many of those homes are still under construction. As more builders gain experience and confidence with these new compliance credits, one may expect to see an increase in duct design testing and envelope sealing.

The EPA/DOE ENERGY STAR® Homes Program incorporates diagnostic testing as a requirement for home certification. The labeling program appears to be gaining momentum as a common platform for designing utility programs. Every major utility in California is instituting programs that promote ENERGY STAR buildings.

The preponderance of diagnostic testing and third-party inspections currently being conducted on residential construction is done in association with energy efficiency programs administered by a utility or governmental agency. However, in the private sector, a few builders test ducts simply to promote quality homes. ConSol's ComfortWise Program stands out as a user-funded initiative that adopts a systems approach, including performance testing, to deliver high-quality, comfortable homes. This program does also receive some utility funding. ConSol reports that diagnostic testing is a growing business. ComfortWise claims to have 6,000 homes in pipeline[3]. Over time, ConSol hopes to secure 20-30% of the new home construction market. ConSol also reports that on-site training in diagnostic testing completed between 1995 and 1998 in California and Nevada was very popular with builders and their subcontractors. Contractors who thought that they were installing tight ducts could see where and how much leakage was occurring (Buildings Industry Institute and ConSol 1998).

b. Impediments to Diagnostic Testing and Third Party Inspections

Despite the apparent benefits of performance testing, the practice has not been adopted on a wide scale to date. There appears to be broad consensus among industry experts on the reasons contributing to its limited appeal.

- Lack of awareness of the extent of construction defects on the part of builders. Performance testing sells what the builder thinks he already gets.
- Lack of awareness of the potential to avoid liability, callbacks, and litigation. Particularly lacking is an understanding of performance testing impacts on indoor air quality, moisture control, health and safety. More research in these areas is needed. According to some reports, indoor air quality may not be an important issue in California due to the relatively dry climate.
- Additional costs, not just first costs, but the costs of marketing. Also, if builders have to include the cost of testing in their bid, it makes them less competitive with other builders who don't use it and have lower costs.
- Unwillingness of home buyers to pay for performance testing. They assume the home purchase price should already cover correct installation. Consumers expect the systems to work, so offering energy efficiency and functional systems as an upgrade has limited appeal.
- Lack of knowledge, skill, and ability on the part of contractors. This barrier may be mitigated by contractor certification, which is gaining momentum through Air Conditioning Contractors of America (ACCA).

[3] Confirmed in discussion with Rob Hammon, August 2000.

- Potential for project delays due to a lack of performance testing infrastructure. Particularly in Southern California, the list of qualified raters is small (except in San Diego County). Builders cannot be certain of existing raters' ability to inspect construction projects without interrupting the work flow.
- Lack of awareness of who the service providers are.
- Lack of standardized methodology and testing procedures that would make the process of diagnostics more efficient, cost effective, and accessible. Also need more uniform standards relating to air pressure balancing (safety issues) and airflow and refrigerant charge. CEE is assembling "national" standards on installation. PG&E is working on uniform standards for installation quality.

Numerous suggestions were also made about how some of these obstacles to increased building commissioning can be removed. These include:

- ➢ Educate builders on the value of diagnostic testing. They need training on how to market benefits of higher quality homes and documentation showing increases in sale value, and reductions in liability.
- ➢ Compile data on the effects of diagnostic testing on the speed of home sales and their sale value.
- ➢ Offset or eliminate testing costs. Selling diagnostics as an energy efficiency program just doesn’t work. The cost is seen as too high even though it is relatively low. To get it off the ground, testing should be free and emphasis should be placed on showing that building quality issues are prime concern. Perhaps offer tax credits for diagnostic testing to offset costs.
- ➢ Include Title 24 specialists in the building process from start to finish. Structural observation should be required of Title 24 specialists so that they ensure the project adheres to their original plan.
- ➢ Simplify the Title 24 codes so that builders can easily understand and comply with them.
- ➢ Utility support is important at first. Conditions for withdrawing utility support: established testing infrastructure, mechanism for continuing education, demonstrable benefits, and lower cost of tests.

- Mandate tight ducts in Title 24. Home builders resist changing construction mandates in the middle of projects but could incorporate testing in new projects.

- Third-party inspections may not be essential. Could have HVAC contractor or builder do testing as long as there is the potential for audit/QC inspections. While overall compliance was found to be low in California, there may be regional variation. SCG's past QC inspections have found good compliance with Title 24

- Provide testing equipment, tool lending program, field training, feedback loops from diagnostic tests to designers.

c. Opportunities to Improve Measure Installation Effectiveness Through Diagnostic Testing and Third Party Inspections

Significant benefits to construction market actors.

Builders are expected to benefit from diagnostic testing significantly. First, reduced litigation is potentially a big benefit because 60% of litigants win. Sources report construction defect cases valued in the $100 millions have been lost in San Diego County. Second is improved customer satisfaction. Customers have tangible evidence of high-quality construction which in turn improves the builder’s reputation. Finally, builders that are known for performing testing distinguish themselves from the pack; their products can be perceived as better.

HVAC contractors are expected to benefit from performance tests. By identifying problems immediately, contractors can reduce callbacks. From the buyer perspective, performance testing improves home quality, particularly if it is done as part of a systems approach to construction. Without testing the mechanical systems, consumers do not know whether those systems work properly.

Provides tangible evidence of measure installation effectiveness.

One of the prerequisites for the successful implementation of a program that promotes greater energy efficiency in houses is a perception of fairness. This is true whether the program is related to code enforcement or incentives for greater energy efficiency. For example, some governmental jurisdictions have experimented with varying electric utility connection fees with the measured energy efficiency of the house. A program such as this requires a precise measurement of energy efficiency for its implementation. Some in the industry are not convinced that a HERS rating alone is a precise enough measuring device on which to base the size or determination of incentive payments. It is felt that when a blower door test is combined with a HERS rating, however, the necessary precision can be attained (Wirtshafter and Hildebrandt 1992). In this way, diagnostic testing could have noticeable impact on measure installation effectiveness.

Directly addresses the systems that promise most cost-effective energy efficiency.

Perhaps the strongest opportunity offered by the use of diagnostic testing is that the most widely discussed tests measure the effectiveness of systems that promise the most cost effective energy efficiency. Simulation results indicate that the most cost-effective energy efficiency measure is the reduction of outside air infiltration. A number of varying steps can be taken to reduce outside air infiltration, however, the effectiveness of all of them can be measured using a blower door test (Wirtshafter and Hildebrandt 1992). Another study indicates that 30% to 40% of residential HVAC energy consumption is lost through leaks in the ducting system due to poor installation. Seventy-five percent of the air loss was from the supply ducts and 25% of air loss was attributed to the return ducts (Syphers, Lekov et al 1998). Duct tests are also among the most widely discussed in the literature. The need for diagnostic testing of ducts is underscored by the wide variation observed in duct system efficiency and envelope leakage levels in different houses (Wray, Piette et al 1999).

Increased compliance with Title 24.

Another way that third-party inspections and diagnostic testing can improve measure installation effectiveness is in increasing Title 24 compliance. Title 24 compliance studies completed in the mid-1990s found that the compliance rate in California houses is the generally low. For example, a 1994 study of 133 buildings found that every building had at least one Title 24 discrepancy, 35 of the 93 residential buildings monitored did not meet overall energy standards (Valley Energy Consultants 1994) Although this may also reflect the complexity of Title 24 and/or the lack of enforcement on the part of building code officials, it still would indicate a need for further testing or inspection of buildings to enhance energy efficiency. A similar study showed homes participating in the Comfort Home Program, which has a third-party inspection and testing component to it, were more energy efficient as measured by Title 24 compliance and duct efficiencies. Participating homes had twice the compliance margin of non-participating homes (Eley Associates 1994).

We concluded that diagnostic testing and third-party inspections warranted additional consideration and testing in the focus groups.

ii. Building Commissioning

As we learned when we initiated this project, there are many different definitions of what commissioning implies. For the purposes of this project, we used the definition offered by Bjornskov, et al. (ACEEE 1996) “Commissioning is a systematic process of assuring by verification and documentation, from the design phase to a minimum of one year after construction, that all building facility systems perform interactively in accordance with the design documentation and intent, and in accordance with the owners operational needs, including preparation of operation personnel.” We consider building commissioning to include the following seven elements:

1. Commissioning plan at the predesign phase

2. Independent commissioning agent from outset
3. Customized test plan as part of project design documents
4. Review systems installation throughout and oversee functional testing
5. Operation and maintenance manuals and plans
6. Training plans
7. Final commissioning report for building owner

Commissioning has historically been done for buildings that have complex energy systems, high energy use, or for owners who value a high quality of indoor environment. Examples of such building types include government buildings and complexes, hospital and healthcare facilities, large commercial buildings, universities and owners who are responsible for establishing on-going building programs. (Dodds, Dasher et al 1998). Big companies, like Genentech, for whom system performance is critical, now practice system-level design and commissioning on a routine basis.

a. Trends in Building Commissioning

While building commissioning has made significant inroads in selected industries, it has yet to become "business as usual." Estimates suggest that less than 5% of all new construction and less than 0.03% of existing buildings are commissioned each year (Dodds, Dasher et al. 1998). Nevertheless there is a significant surge of interest in commissioning and recommissioning of buildings, which is being driven by energy efficiency and indoor-air quality (Claridge, Haberl et al. 1994). Expert informants cited a number of qualitative observations that indicate growing interest:

> "There seems to be more and more instances of case studies and success stories. At the National Commissioning Building Conference every year there are more participants. It's not just a small group."

> "It's finally growing because technology is improving. Some systems now you have to commission just to make sure they work, not just whether they are installed properly or to function most efficiently."

> "People are beginning to understand how and what it means to commission a building. People are learning about it through utility workshops, trade journals, ASHRAE, commissioning conferences, and indoor air quality forums."

"There is an opportunity for improved energy efficiency in the retrofit market. Property management firms and real estate holding companies have an interest in reducing operating expenses and can often be interested in improving their buildings."

b. Impediments to Building Commissioning

Despite the growing interest, there remain a number of significant market barriers to widespread adoption of building commissioning. Many studies list barriers to successful commissioning such as

- No one wants to take responsibility for building performance problems. In the current construction process, there is handoff among many players and accountability is lost.
- Additional project costs associated with commissioning, in the form of extra time and paperwork. Builders don't budget for it; they don't see commissioning as part of the construction process. Marketing it is expensive.
- Lack of awareness of the energy benefits and long-term economic savings benefits of commissioning. Building owners do not see the value of commissioning and they think they should not have to pay extra for something that should be included in the initial purchase (the assurance that the systems are installed properly). Owners do not see the value of asking for it and builders do not push it because they do not realize the value.
- Lack of a clear understanding of what building commissioning implies. The market actors do not all realize that buildings have become far more sophisticated and old practices are not enough. There is no commonly agreed definition of commissioning.
- Lack of commissioning expertise. Those conducting the commissioning lack knowledge of what to test and how to test it.
- Lack of a standardized methodology and testing procedures that would make the process of commissioning more efficient, cost effective and accessible. The IPM&V Protocol is an overly expensive standard for testing. Simpler protocols would address majority of problems with minimal effort. Commissioning advocates want expensive M&V (measurement and verification) to avoid risk. But the industry needs simpler M&V tools and procedures to make commissioning affordable.

- Skepticism on part of building owners and managers that a proposed Energy Conservation Measure (ECM) is going to work. People feel like they would be paying for something they should already be getting.

Numerous suggestions were also made about how some of these obstacles to increased building commissioning can be removed. These include:

- Make additional commissioning information more readily available (guide specifications, commissioning plans, guidelines, test procedures). Common training material developed by the Association of State Energy Research and Technology transfer institute with funding from U. S. DOE was successfully used in the Northwest and Wisconsin (Dodds, Haasl et al 1994). Perhaps develop a handbook that tells exactly when/where/how commissioning should be within the construction process. Perhaps develop metric for measuring the benefits of commissioning as part of DOE's International Performance Measurement and Verification Protocol.

- Facilitate training/certification for building commissioners by state. Maybe let private sector and/or universities handle this but maybe have the code define what is expected by commissioning. Ideas are: design an internship program or introduce commissioning into the standard curriculum for architecture and engineering programs; develop one-day lesson plan materials for commissioning to increase the likelihood that faculty would include commissioning in their course work.

- Initiate studies on costs and benefits of building commissioning, including a quantitative cost-benefit analysis of commissioning relative to 'non-energy' benefits, such as improved air-quality, better work environment resulting in higher productivity. (Dodds, Dasher et al 1998).

- Involve the federal government to promote commissioning through marketing efforts, provide funding for commissioning, demonstration projects, cost-effectiveness studies, develop a commissioning curriculum for engineering and architecture programs, requiring commissioning of all government performance contracts-especially for military bases.

- Incorporate commissioning into current energy programs, such as EPA's ENERGY STAR Building and Labels programs and Green Buildings program. Third-party initiative program gives smaller contractors and independent firms a chance to learn about better marketing skills and about building "tune-ups" or recommissioning.

- Tax incentives or other financial incentives were identified as an important strategy that the federal government could use to encourage building commissioning (Kunkle, York 1999).
- Encourage mechanical engineer involvement throughout building process. Start at the design phase and look for opportunities to optimize performance through the installation process. The key intervention often involves getting the mechanical engineer on the right track to design an energy-efficient system.
- Leave commissioning to private market actors. If we let “quality performers” do the commissioning themselves, they will do it, and they will do a good job. Many of the quality contractor firms will learn how to commission simply to carve out their own niche and make a name for themselves as quality builders. They will use it as a selling feature for their services.
- Educate all market actors. Educate the owners and architects and engineers and standardize the commissioning process in general.
- Offer small incentives for testing rooftop units.
- Simplify the protocols. Simpler protocols would allow the industry to capture 80% of the benefits with only 20% of the effort. Develop simpler monitoring equipment and software for analysis. Need to automate monitoring activities.
- Air quality and productivity issues provide particular opportunities to link building commissioning with insurance liability issues. Quantifying those links will be difficult but worth it. Insurance industry executives have already shown interest in funding additional research, though they may not yet be ready or willing to lower rates for commissioning.

c. Opportunities to Improve Measure Installation Effectiveness Through Building Commissioning

Benefits for builders.

If buildings are commissioned they have proof of being better buildings. They should have lower insurance/liability. The quality of the building is better. Customer complaints will be reduced. Many of the quality contractor firms will learn how to commission simply to carve out their own niche and make a name for themselves as quality builders. They will use it as a selling feature for their services.

Increased understanding of the value to market actors.

Making building commissioning a requirement will focus attention on the need for both consumer and builder/contractor/inspector education. These resources will become more readily available, perhaps through PGC funds at first and then by trainers/providers seeing an opportunity to sell their services. Making information and training more readily available increases the likelihood of use.

Encourage building design to address energy efficiency and achieve it.

Commissioning allows accountability and documents design intent so the end result mirrors the initial design. Provides feedback too for construction team so they know where the problems exist; documents the front-end information and reconciles it at the end.

Focus on major factors in energy use in buildings.

Effective commissioning of building HVAC and control systems has been increasingly identified as a major factor in ensuring the energy effectiveness of the building. Proper commissioning reduces energy consumption, increases occupant comfort, improves indoor air quality, and lengthens the life of equipment. Significant amounts of energy are wasted each year in commercial buildings due to inefficient operation of HVAC equipment. Increased energy consumption of 10–35% is not uncommon due to what appear to be minor adjustments to equipment and controls. Commissioning on buildings at Texas A&M found that they saved 28-50% on average in some situations.

We concluded that, using the suggestions for improving the acceptance of building commissioning, this intervention candidate warranted additional consideration and testing in the focus groups.

iii. Links to Liability Concerns

While there are many aspects to construction liability, many of them are not related to energy efficiency. Our review of liability concerns covered both residential and nonresidential construction. We focused on the key measures identified earlier: building envelope (residential), lighting control systems (nonresidential), and HVAC installation and design (both).

Types of liability insurance related to energy efficiency include:

- *Completed operations liability:* This insurance provides coverage for bodily injury and property damage arising from completed or abandoned operations, provided the incident occurs away from premises owned or rented by the insured. The best way of avoiding these problems is making sure the equipment is designed and installed properly, the focus of building code development and compliance, as well as standard measurement and verification protocols. In addition, because indoor air quality illnesses can result in large insurance losses, reducing the strength of indoor pollutant sources is commonly the best method to reduce indoor air pollution.

- *Comprehensive general liability:* This insurance means that the insurance company will pay all sums the insured becomes legally obligated to pay as damages due to bodily injury and property damage.

- *Contractors liability:* Contractors are liable for damages resulting from bodily injury and/or property damage caused by an insured peril and arising out of the ownership, maintenance, or use of premises and operations in progress. Building code development and compliance, measurement and verification protocols, energy management and control systems, building commissioning, as well as reduction of indoor air pollution and radon resistant housing are all examples of how this insurance loss can be avoided.

- *Product liability:* Product liability is the liability for bodily injury or property damage incurred by a merchant or manufacturer as a consequence of some defect in the product sold or manufactured, or the liability incurred by a contractor after he has completed a job as a result of improperly performed work. Building commissioning is a process that can reduce product liability claims by making sure that equipment (and the building) is operating as designed.

a. Trends in Linking Effective Measure Installation to Liability Concerns

Builders are starting to see the benefits of improved measure installation in terms of reductions in liability and insurance premiums.

- Improved construction reduces callbacks and litigation costs for both builder and contractor. More and more, builders are looking for ways to cut costs and the high-quality builders see that these reductions can help do that.

- Virtually every category of insurance (from property and liability, to health and life) benefits from better construction practices. In particular, lower claims in professional liability for builders is significant.

b. Impediments to Linking Energy Efficiency to Liability Concerns

- There is a consumer perception that energy efficiency “improvements” can go awry and lead to fire, sick building syndrome, etc. While not entirely true, this is not entirely false either.

- It is important for people in the energy efficiency arena to be aware of the potential risks involved with being more energy efficient. For example, vinyl windows are heavily promoted in the energy efficiency arena but they melt and can cause fires. Tighter sealing can result in air-quality issues.

- Insurance premiums are differentiated to support loss control, to reward low-risk customers. Need data to justify reductions in premiums.

- DOE Building America program claims to have reduced callbacks but offers no data.

- Insurance carriers interested in actuarial data to justify reducing premiums for builders who use improved construction methods.

- Costs are tangible but benefits are fuzzy. Extra costs include tight ducts, Low-e glass (for low heat gain), installation protocols for insulation, diagnostics.

Suggestions were made about how to promote higher quality construction as a means of reducing insurance premiums and losses and managing risk. These include:

➢ Provide long-term warrantees on new homes.

➢ Document benefits. Data should be actuarial quality and should document benefits from reduced litigation exposure. The insurance regulators need to be convinced that this is a good thing. There is not much quantitative data on this yet.

c. Opportunities to Improve Measure Installation Effectiveness Through Links to Liability Concerns

Insurance carriers interested in actuarial data to justify reducing premiums for builders who use improved construction methods. This creates the potential for improved measure installation to reduce insurance.

Provides ongoing benefits to builders.

Linking premiums to quality and efficiency would give a much stronger signal than utility rebates. Unlike rebates, insurance credits are recurring so they would repeatedly incent.

Helps builders meet their own business objectives.

Building codes in particular can "join forces" with the insurance community and it's really a natural link. The issues that are faced by the energy and insurance industry are not unlike those faced by this community. For example, if you have missing insulation, it is not only an energy efficiency issue, but an insurance issue as well.

We concluded that linking quality construction with liability concerns warranted additional consideration and testing in the focus groups.

iv. Links to Financing

Energy efficient mortgages (EEMs) provide mortgage insurance to purchase or refinance a principal residence and incorporate the cost of energy efficient improvements into the mortgage. All buyers who qualify for a home loan qualify for the EEM. The EEM is intended to give the buyer additional benefits on top of their usual mortgage deal. The lender will use the energy efficiency of the house, as determined by a HERS rating, to determine what these benefits will be. Energy efficient mortgages can be done on most homes, and availability is not limited by location, home price or utility company.

Homeowners and home buyers generally have two sources of loan options to improve their homes: through federally-sponsored programs or through private loaning institutions (including utility programs). These options are discussed in the Literature Review appendix to this report.

a. Trends in Linking Effective Measure Installation to Financing

Interest in providing consumer financing for energy efficiency improvements began back in the 1970s during the energy crises. When energy efficiency financing was first introduced in the early 1980s, it exhibited very little success. Most of the literature reviewed attributes this not to lack of interest, but rather to several other factors, including perception of increased risk to the lender and lack of consistent energy rating systems or trained raters.

Since about 1992, there has been another push in the marketplace for energy efficiency financing programs. More market actors are getting involved, and lenders and consumers alike are beginning to see the value of owning a more efficient home, however participation in such programs continues to be low. The following sections describe the latest types of energy efficiency financing that currently exist in the market place, as well as the barriers that continue to impede the programs.

Strides have been made in reducing resistance to EEMs. First, there have been numerous industry-based groups established, dedicated to removing market barriers, promoting energy financing, helping to create other rating organizations, and promoting energy ratings at national and local levels. Also, federal agencies seem to have shifted their focus from being regulators in the 1970s to facilitators in the 1990s. With the establishment of the ENERGY STAR Homes program, for example, EPA is working to promote efficiency and increase market demand, rather than simply regulate what efficiency guidelines and standards should be. Nonetheless, EEMs have not really taken off.

b. Impediments to Linking Energy Efficiency to Liability Concerns

There are apparently considerable obstacles to linking improving construction practices to financing. Reasons why lenders might not offer EEMs include:

Real estate professionals are not very informed about the availability of EEMs and how to use them in marketing real estate.

- Most builders are not aware of the benefits of EEMs. Resnet.com did a survey where they hypothesized that 100% of those applying for home mortgages would have received $5000 more through an EEM.

- Lack of adequate funding to successfully market EEMs to consumers and small profit potential. Lenders do not view energy efficiency financing as a profitable lending area due to overall weak consumer demand.

- Energy efficiency documentation creates additional paperwork and can slow a loan process already overburdened. There is a perception that EEMs require a lot more paperwork than they actually do.

- Commonly used lender and real estate forms do not convert readily to include financing of energy-efficiency products.

- Perceived risk--the secondary mortgage lenders have little enthusiasm for energy efficiency loans because of the increased potential for loss if the loan defaults (Verdict 1996)

- Appraisers don't consider energy efficiency improvements in assessing home.

- Need cooperation from both lenders and Realtors. Realtors are not interested because auditors come in and have to deal with disclosure issues which can jeopardize the sale.

- Most lenders don't really care about energy efficiency. Their bonuses are tied to the bottom line ($$). That is why a lot of energy efficiency projects don't go through. Energy efficiency is not valued as important.

- With respect to lenders, barriers can not be overcome with the types of programs we've seen in California. Must convince lenders that there is value in commissioning; that it makes sense from a financial point of view.

- In some cases, lenders have said they need simple tools that simply measure and then they need to be able to compare their building against other buildings. There needs to be a baseline and a way to compare that baseline to make sure it if meaningful.

Suggestions were made about how to encourage the availability of EEMs. These include:

- Certifications for products they install (e.g., HVAC contractors), making them test for and receive a certification at the federal level. This would also ensure common best practices.

- Policy intervention at the level of the national appraisal foundation. They are working with them already to put in uniform appraisal factors. If energy is introduced, it would overcome some of these barriers. One policy option under consideration is that of the Wall Street Initiative. This would be to standardize the way appraisers report line items. Appraisers, unlike other market actors, operate under standard rules, forms, etc. There is a lot of leverage there to introduce such things as energy into policy options.

c. Opportunities to Improve Measure Installation Effectiveness Through Links to Financing

According to one author, significant marketplace changes and removal of institutional barriers are causing renewed interest and guarded optimism about the future of energy efficiency financing (Verdict 1996).

There certainly are potential benefits to lenders. But, as one industry expert put it, “The benefits are not that great, and certainly not that obvious.” Lenders can use EEMs as a sales tool to differentiate themselves from others. The projects are much larger, so profits are likely to be greater.

We concluded that linking quality construction with financing was not promising enough to warrant additional consideration and testing in the focus groups.

v. Links to Other Building Energy Efficiency Programs

Efforts to improve building construction and the standards process might be linked with other energy-efficient building and “green” building initiatives. We reviewed several programs in or near operation. These were:

- CHEERS
- City of San Jose Green Buildings (program under development)
- City of La Quinta
- City of Irvine IQ+ Construction Quality Building Program
- City of Santa Monica Green Building Program
- County of Santa Barbara’s Innovative Building Review Program (provides incentives for buildings that exceed Title 24 by 20%, 30% and 40%)
- ComfortWise (Consol’s privately run, residential new construction DSM)
- State of Minnesota Department of Public Services (state energy code which includes diagnostic testing requirements for residences)
- Sacramento Municipal Utility District (residential and nonresidential new construction program)

- Texas Lone Star Program
- Local Energy Assistance Program
- Certified Plus Home Program in Fresno
- PG&E programs:

    Comfort Home (Central Valley)

    ENERGY STAR (CHEERS raters inspect ENERGY STAR homes)

    Savings by Design

    Local Government Initiatives Program

    Codes & Standards Program

Our literature review and interviews also revealed a number of other programs underway or under development throughout California, including: programs in Anaheim, Chula Vista, Carlsbad, Santa Clarita, and Riverside County. A further development in creating links with the standards process is the increased coordination in efforts among utilities, the CEC, and Building Industry Institute (BII). Additional programs operated by the California IOUs are described in Appendix E.

a. Program Goals and Incentives to Builders and Developers

- Simple program application process (1 sheet, 2-sided). Sets three targets for increasing green building construction. Rewards each with increasing benefits. Targets reached by exceeding Title 24 and scoring energy points, as defined on the application sheet. Target 1: 20% beyond Title 24 and 4 energy points. Target 2: 30% beyond Title 24 and 12 energy points. Target 3 40% beyond Title 24 and 30 energy points.
- Nonresidential projects can get credits for low-emission paints and solvents, water conservation measures, and construction waste management plan.
- Key benefit is quicker approval process which can save several weeks. Note that the building permit process is expedited but not the planning review process.
- Goal for city’s Green Building Program is to achieve efficiencies that exceed Title 24 by 25%. The program is for multi-family housing and commercial new construction.

- Examined possibility of incenting developers to exceed Title 24 but learned that it would be far too expensive (incentives totaling at least 3% of total project costs). Wanted to avoid developing a program that simply offered a prescriptive process by which builders could just barely meet the minimum requirements.

- The Green Building Program has very few rules and is not based on Title 24. It simply states that the resulting building must achieve performance levels that are 25% above Title 24. The Program results in an Energy Performance Ordinance. Specific equipment types and/or materials are not specified (as in Title 24). The city has developed a "cookbook" of green building practices that was peer reviewed by green building experts.

- San Jose Green Building program includes all players in the construction market; architects, engineers, Realtors, builders, building owners, homeowners, educators, loan agent, etc. Incentives are not yet finalized but all players are being asked how they might best benefit from a "green" building program.

- Program has a review committee that reviews plans, assigns points. Program encourages preliminary review before serious design. Committee has a Title 24 consultant. Once project plans are scored, building inspector can check that scored items actually implemented.

b. Problems and Challenges Implementing Programs

- Project needs to identify more incentives to participate. Eventually improvement in marketability of buildings should add partial incentive to participate.

- Program needs to develop better-documented relationships between point assignments and measure benefits. Need lifecycle call back analysis of measures. Currently, point structure based on expert judgement.

- Any statewide program should offer flexibility to address local land use, water issues. Program would need education component for builders/developers. Need case studies by climate zone, demonstration projects, monitoring studies.

- CEC can facilitate but not mandate non-energy benefits. California needs a state ombudsman for all resource conservation who can review all kinds of technologies and construction practices for range of resource conservation benefits. (e.g., low-flow showers, toilets, composting toilets).

- Architects and builders have great flexibility with program but the implication is that they must understand energy issues and the impact of design and system changes. To help, city has developed a software program that will be made available free of charge. The software assists users in testing their projects and is also capable of suggestion changes. Software is available free of charge.
- The city will require that all proposed projects be modeled at the permitting stage so that their compliance with the Energy Performance Ordinance can be determined.
- In recognition of the difficulty of executing the program, the city plans to invest in training and educating their own building inspectors.

We concluded that linking quality construction with other energy efficiency programs was not promising enough to warrant additional consideration and testing in the focus groups.

C. Opportunities to Influence Standards

i. Overview of Standards Development and Implementation Processes

The CEC as well as other government agencies, utilities, and third parties all contribute to the development and implementation, including enforcement, of the California building standards.

a. CEC Role in Standards Implementation and Development

The CEC contributes to the standards implementation process in two key ways—by offering training courses for energy consultants, building officials, HERS raters, contractors and other building industry market actors; and through the following technical assistance and implementation support mechanisms:

- Preparation of residential and nonresidential manuals: The *Nonresidential Manual for Compliance with the 1998 Energy Efficiency Standards* is provided to meet the requirement of this section. The Manual includes compliance method descriptions, calculation procedures, technical data, examples, and sample compliance forms for meeting the standards for nonresidential buildings, high-rise residential buildings, and hotels/motels.
- Development of an alternative calculation method and associated software: The Nonresidential Alternative Calculation Method (ACM) Approval Manual is intended strictly for those persons who want to design a calculation computer program for use with the energy standards.

- Compilation of a list of approved computer programs for determining building compliance with codes

- Maintenance of an information hotline: The Energy Hotline is run by the California Energy Commission's Efficiency Division, and provides callers with comprehensive and timely technical information on how to comply with the Title 24 Building Energy Efficiency Standards and information on appliances certified for sale in California. It is used daily by hundreds of utility, building and energy professionals.

- Publication of a regular newsletter, *Blueprint*, for building professionals.

- Publication of the *Home Energy Guide*, which provides energy efficiency tips for homeowners.

- Publication of *Six Steps to an Energy Efficient Addition*, which provides guidance to homeowners for completing energy compliance forms: This step-by-step guide aimed at helping homeowners correctly fill out detailed forms. It is currently under construction at the CEC website.

- Certification of home energy rating services: These services are to also include field verification and diagnostic testing available through Commission-certified providers and their raters when duct efficiency and envelope leakage measures are installed for complying with the new 1998 building efficiency standards (effective July 1, 1999).

- Establishment of protocols for "Quality Homes" technique to verify quality residential construction with diagnostic tools This online resource provides techniques to verify quality construction with diagnostic tools, and includes: protocols for energy-efficient residential building envelopes, procedures for HVAC system design and installation.

- Compilation of a roster of certified energy plan examiners for residential and nonresidential buildings: This online roster contains the names of individuals who have satisfactorily completed a voluntary certification program in which they have demonstrated a broad understanding of how to prepare and review building plans.

- Publication of a directory of certified equipment for residential space conditioning and water heating: This is an online directory that allows users to access listings of appliances which exceed California and federal appliance efficiency standards.

In addition to ongoing standards implementation activities, the CEC manages a standards development process that produces revisions to the standards every three years. Activities associated with this process are cyclical in nature. A partial listing of CEC activities associated with the process includes

- Sponsorship of public workshops and hearings to address building energy research findings, compliance option development, public domain and approved calculation methods, HERS rating program regulations, and standards updates and
- Research and development related to building energy problems (e.g., the PIER program) and possible solutions to those problems through, among other things, standards changes.

Interested parties may submit proposals for changes to the standards to the CEC at any time. Proposals are reviewed by CEC staff, discussed in public hearings, and voted on by commissioners. Typically, hearings are attended by interested parties in the building industry such as manufacturers and professional associations for builders, contractors, and Title 24 consultants.

b. Other Government Agency and Market Actor Roles in Standards Implementation and Development

In addition to CEC-sponsored support activities, a number of other agencies and market actors play a role in the standards implementation process. Local government building officials play a primary role in enforcing the standards through plan checks and field inspections. BII, various utility programs, and the CHEERS program all engage in training energy consultants, building officials, HERS raters, contractors and other building industry market actors. Various utility programs also include compliance checking, diagnostic testing, HERS rating, and builder promotion assistance to market homes that meet and exceed the standards.

Enforcement is primarily the purview of local planning departments. The Warren-Alquist Act, chapter 5, section 25402.1, subdivision (g), states that "[n]o building permit for any residential or nonresidential building shall be issued by a local building department, unless a review by the building department of the plans for the proposed residential or nonresidential building contains detailed energy system specifications and confirms that the building satisfies the minimum standards established pursuant to subdivision (a) or (b) of Section 25402 and this section applicable to the building."

California utilities have had and continue to have a role in the development and implementation of building standards. We examined this role in greater depth in both our literature review and industry expert interviews, paying particular attention to the potential for expanding and increasing the effectiveness of their role. The role of utilities in the standards process is discussed below in the section on opportunities to influence the standards.

When polled about their top priorities for future changes in the standards, representatives from California utilities, local government agencies, and third-party providers offered the following suggestions:

- Have the standards include Time Dependent Valuation (TVD), which opens the door to load shifting measures. During the last round of T-24 revisions, PG&E's T&D staff apparently pushed for inclusion of demand issues in Title 24. The cost of generating electricity varies by time of day and by season. These variations should be reflected in cost-benefit calculations that determine whether measures are cost effective for inclusion in Title 24.
- Model true performance of residential HVAC (nonresidential modeling just needs fine tuning). Avoid relying on bulk seasonal efficiency metrics such as SEER, AFUE, energy factor).
- Reduce nonresidential lighting power density
- Residential windows
- Residential insulation quality
- Shift tight ducts from ACM to mandatory measure
- Require commissioning and third-party inspections (but do not bypass local jurisdictions)

c. Barriers to Effective Implementation and Development of Standards

Despite the apparent benefits standards offer to energy efficiency, a number of barriers exist to their effective implementation. From the literature and our interviews, several problems were commonly cited, including:

- Complexity of the standards.
- Lack of understanding about the standards by builders, contractors, and designers.
- Low public support stemming from lack of understanding about benefits the standards provide.

- Irregular or inconsistent enforcement of the standards by local government, due to lack of interest or insufficient personnel.

- Infrastructure that does not encourage involvement of various stakeholders in suggesting changes to the standards. It was said that the CEC develops proposed changes and particularly wants to avoid new issues being raised at the hearings or Order Instituting Rulemaking (OIR) proceedings.

- Lack of availability of or consensus on computer software appropriate for calculating the impacts of proposed changes. It was suggested that this thwarts stakeholders' involvement in proposing changes to standards.

ii. The Relationship Between Standards and Energy Efficiency Programs

a. Expected Influence of Program Elements on the Standards Process

Tables 4 through 6 summarize key PG&E programs and program elements expected to have an influence, either direct or indirect, on the code process. The assessment of expected influence is based on a review of PG&E's 1999 Advice Filing. We elected to focus on 1999 because the program changes between 1998, 1999, and 2000 are relatively minor and because 1999 was the first advice filing following CBEE's October 16, 1998 Advice Letter, making it a reasonable representative of the planning efforts in other years since the shift toward market transformation.

We chose to focus on PG&E programs because PG&E programs are, for the most part, representative of the program plans for both PG&E and SCE in PY1999 and PY2000. The advice filings from the two largest utilities show abundant evidence of close collaboration and a distinct shift toward statewide programs. SDG&E program designs are generally consistent in design but relatively narrower in the scope of their activities. SCG program designs were less well developed at the time this assessment was performed though we have learned that SCG has committed to making some substantial changes in their 2000 program.

Influence can take a number of forms, including commercialization of an emerging technology, developing widespread acceptance of a technology or practice that is a candidate for coverage in the codes, educating practitioners and code enforcement officials, or otherwise facilitating proper code application and good design practice. The tables include only nine of the fourteen programs called for in the CBEE Advice Letter. The remaining programs were judged to be unrelated to the scope of the Codes and Standards MA&E Project. For similar reasons, individual program elements were excluded if they were judged to be unrelated to the project scope. Excluded programs were Nonresidential Motor Turnover, Nonresidential Process Overhaul, Residential Lighting, Residential Appliances, and Industrial and Agricultural New Construction.

Along with CBEE programs and program elements, the tables show PG&E's proposed program interventions for PY1999. Again, only selected interventions have been included, based on their expected ability to influence the code process. As noted above, the interventions shown are, for the most part, representative of the program plans for both PG&E and SCE in PY1999 and PY2000.

A summary of utility programs and training offered is in Appendix E. They also regularly participate in Title 24 workshops, provide regulatory testimony and product and conduct additional activities to directly influence the development code, especially through the activities of the Codes and Standards Statewide Committee.

Table 4. Nonresidential Program Area Intervention Strategies Expected to Influence the Code Process

Program	Program Elements	1999 PG&E Intervention Strategy
Large Nonresidential Comprehensive Retrofit	Integrated C&I HVAC and Lighting Comprehensive C&I Lighting Retrofit Energy efficiency Centers	Pacific Energy Center Design and analysis tools, including Lighting Exchange and Cool Tools Project
Small Nonresidential Comprehensive Retrofit	Integrated C&I HVAC and Lighting Comprehensive C&I Lighting Retrofit Energy efficiency Centers	Pacific Energy Center Design and analysis tools, including Lighting Exchange, Cool Tools Project, Daylighting Initiative, Natural Cooling, and Commissioning and Performance Evaluation Tools
Nonresidential HVAC Turnover	High-Efficiency Equipment Sizing, Controls, and O&M	Design and analysis tools
Commercial Remodeling / Renovation	High-Efficiency (Lighting) Equipment High-Efficiency Design	Pacific Energy Center Design and analysis tools, including Daylighting Initiative

Table 5. Residential Program Area Intervention Strategies Expected to Influence the Code Process

Program	Program Elements	1999 PG&E Intervention Strategy
Heating and Cooling	Efficient Residential Equipment Information and Education Improved HVAC Sizing and Installation Practices Linked HVAC Financial Incentives Regional and National Initiatives	Targeted information to HVAC market actors ENERGY STAR brand promotion to consumers Training, certification and/or inspection for HVAC market actors Technical assistance and sales tools Regional/national strategies for HVAC
Retrofit and Renovation	Promotion and Facilitation of Comprehensive, Discretionary Retrofit Service Facilitation of Efficiency Retrofit at Time of Sale or Renovation Energy Efficiency Centers	Targeted information to consumers planning home purchase, sale, renovation Third party contract for institutionalization of HERS, EEMs Third party contract to work with home improvement centers Stockton training center contractor training Building official training on codes and standards Third party contract with California Window Initiative

Table 6. New Construction Program Area Intervention Strategies Expected to Influence the Code Process

Program	Program Elements	1999 PG&E Intervention Strategy
Residential New Construction	Targeted Consumer Promotion and Information Infrastructure and Product Development Integrated New Home Product Capability Development Market Leader Incentives	Targeted information to consumers in market for new home Promotion of ENERGY STAR Homes label Incentives to third party builder allies CHEERS ENERGY STAR builder sales agent training and tool Training and technical assistance to builders and HVAC subcontractors Builder resource guide
CommercialNew Construction	Large Comprehensive Small Comprehensive Prescriptive Energy-Efficiency Center	Savings by Design technical and design assistance Targeted information and design incentives Design and analysis tools, including Cool Tools Project and Commissioning and Performance Evaluation Tools
Codes and Standards	New Construction Codes and Standards Support Local Government Initiatives	Code training and public education Develop voluntary design guidelines that exceed current requirements Information, assistance, incentives during local government planning and development process Links to third party financing for building retrofits

b. Opportunities for Standards to Help Meet Program Objectives

The literature supports the general conclusion that energy standards offer significant opportunities for advancing the market transformation objectives of PGC-funded programs. Nadel (1992) argues for a symbiotic relationship in which regulators weave strong energy saving options into codes and utility/MT programs then use these optional measures as the basis for incentive programs.

Northeast Energy Efficiency Partnerships (1998) notes that "code activities are not a substitute for new construction/renovation energy efficiency programs, but they can reduce the scale of such programs, make them more cost-effective, and provide an exit strategy for continuing incentive obligations for accepted technologies. Effective and universal code enforcement raises program baselines and reduces freeridership." According to NEEP, energy standards offer at least three specific benefits to energy efficiency programs:

- Financial: When programs have largely succeeded in changing standard practice, continued program efforts may experience reduced effectiveness in stimulating new builders and developers to adopt measures. Standards can "lock in" past program accomplishments and permit the program to shift resources toward new energy efficiency opportunities.

- Equity: Program efforts tend to influence the largest, most aware, or most progressive market actors. Energy standards can extend program achievements to include rank-and-file market actors who tend to build to the minimum standards.

- Level playing field: In competitive bid situations, designers are reluctant to add measures that may save energy but have a higher first cost for fear of losing the bid. When high efficiency measures are required by code, these pressures are diminished.

This conclusion was supported by Nadel (1996) and Harris and Mahone (1998) and by many of the industry experts we interviewed. In particular, the interviewees noted

- Standards serve to set a baseline that programs can use to set higher energy-efficiency goals. It was mentioned that using codes started as early as 1979 with solar energy programs striving to exceed the code. The County of Santa Barbara's innovative building review committee provides incentives for buildings that exceed Title 24 by 20%, 30%, and 40%. EPA ENERGY STAR homes are required to exceed Title 24 requirements by 20% to 25%. The City of San Diego's green building policy requires all municipal buildings that are built or retrofit to perform 50% above Title 24. The standard provides important benchmarks that programs can use to push practices to higher energy efficiency.

- Standards support utility programs by serving as an exit strategy.

- Standards have had the effect of encouraging the use of newer technologies, the same thing that programs were trying to do. People might not use them unless required to do so and standards provided the push.

- Without codes and standards, one market actor mentioned, energy efficiency would never "take off." Standards have been important in moving consumers and the building industry toward energy-efficient practices.

- The alternative compliance methods allowed in Title 24 help achieve higher energy efficiency. One interviewee gave the example of window shading. Window covers never gained acceptance but flexibility in the compliance measures allowed builders to do something else to attain the same energy efficiency.
- Another interviewee suggested that the standards define the terrain and the programs find niches to satisfy the standards.

Finally, NEEP notes that "the appropriate relationship between building energy codes and utility programs is for the code to require all energy efficiency measures that are now cost-effective for building owners and are common practice in the market, and for utilities to offer incentives only for those measure which exceed code, are cost-effective for society, and which need a 'market push' to lower unit costs and gain recognition and acceptance in the marketplace."

iii. Opportunities for Programs to Influence the Standards Process

The literature review and our interviews with industry expert yielded a number of suggestions and examples of how PGC-funded programs can influence the development and implementation of standards in California. These suggestions provided the basis for some of the recommendations we ultimately tested in the focus groups, described in Section 4.

Both Northeast Energy Efficiency Partnerships (1998) and Heschong Mahone Group (1998) argue in favor of energy efficiency program interventions to support standards activities. NEEP identified six strategies for northeast utilities to pursue in support of energy standards, five of which seem applicable to California's utilities and PGC-funded programs.

- Participate in standards upgrade efforts. Programs can provide data on baseline new construction standards, make technical and program staff available to aid in the upgrade process, and provide testimony or letters of support for standards upgrades.
- Target program activities toward emerging technologies or design techniques that are not yet standards requirements.
- Raise public awareness of standards requirements.
- Assist in trade ally training programs.

- Assist in standards administration and enforcement. Utilities can require certification of standards compliance as a precondition to electrical service hook-up. They can also fund a technical consultant to work with developers and building inspectors to help projects meet standards requirements. Finally, they can contract with government to perform standards compliance services such as plan reviews and site inspections.

Similarly, Nadel (1992) identifies a number of options for improving coordination between energy codes and utility/market transformation programs, including

- Utility advocacy of code enhancements by proposing code changes, providing analysis of the costs and benefits of proposed code changes, and providing testimony at regulatory hearings
- Utility/MT promotion of new, stricter codes after they are promulgated but before they become mandatory
- Use of MT funds to offset code adoption costs, offer code official training, offset increased inspection costs, provide technical support, and offer incentives to cover increased building costs for the transition period
- Utility/MT promotion of Reach codes on a trial basis
- Use of sliding scale hook-up requirements and fees based upon level of code compliance

Additional opportunities suggested by the industry experts we interviewed include

- Utilities can provide support for future revisions to standards by helping CEC work around its contracting problems and augmenting CEC research activities (e.g., residential quality assurance project).
- Utilities can help day-to-day implementation of the standards by supporting local jurisdictions and the building community. For example, the City of Irvine has developed a program which refunds energy plan check and energy inspection fees to builders who participate in their program. This is an example of how a program supports compliance with the standard.
- Utilities can effectively assist in trade ally training programs. Field experience in North Carolina and Florida shows that HVAC contractors, after completing program-sponsored duct installation training, continued installing tight duct systems without any utility incentive.

- Ongoing educational services are needed to account for turnover within the building design and construction community and to cover changing in the code. Utilities can help implementation by assisting with that education process.

- Members of the public may not see or understand the public benefits standards provide. As a consequence, they may perceive energy standards as social engineering or unnecessary government intervention. Programs that educate the public regarding the benefits of energy efficiency can help further the standards development and compliance process by improving receptivity to the standards.

- Code simplification is critically important. Most of the jurisdictions studied are looking for simplification of the energy standards (Valley Energy Consultants 1993). The less complex the code or standard, the greater it appears that it will be used and/or enforced (Crowder and Foster 1998). It is clear from both the building and enforcement communities that the energy code needs to be simplified. This includes the code itself, compliance forms and enforcement techniques. Experience in Oregon documented by the latter indicates that the effectiveness of the code is improved when it is simpler to understand and apply. To the extent that programs can be used to develop better working relationships the governmental agencies that determine the codes and builders and contractors who use the codes, programs can establish the infrastructure needed to forge simplifications to the codes that can satisfy both the code setters and code users.

- Programs can provide data on baseline new construction standards, make technical and program staff available to aid in the upgrade process, and provide testimony or letters of support for standards upgrades. R&D has produced useful input to DOE standards. For example, a lab was built in San Ramon to simulate temperatures and compared SEER 10 to SEER 12 air conditioning units. Results showed that SEER 10 can out-perform SEER 12 at higher outdoor temperatures. This suggested that the Title 24 standard should be based on tests at high temperatures (e.g., minimum standard-SEER 10 and EER = x @ 95 degrees). CEC, NRDC, Oregon State Energy Commission, ACEEE all support the use of programs and R&D to support standards development.

4 DEVELOPMENT AND TESTING OF CANDIDATE RECOMMENDATIONS

A. Concept Design and Testing

Throughout our study we acknowledged that energy efficiency is strongly influenced by three main factors: design, choice of materials and technologies, and construction practices. The main focus for this study was on construction practices because in our view those are the hardest issues to regulate in Title 24 language. We were interested in design elements as well, but only to the extent they play a role in energy efficiency. We focused less attention on materials-not that they are not important, but we were informed early on of other studies with that focus. That said, we developed a list of concepts or potential recommendations to test on various market actors. These were based on the results of the literature review and in-depth interviews as discussed in Section 3.

The conceptual recommendations focused on three distinct areas: residential diagnostic testing, nonresidential building commissioning, and insurance liability. Most of the recommendations would require development of infrastructure to be implemented effectively, so we identified whether we considered the recommendation to be a short-term, medium-term, or long-term solution. In testing each concept we told the focus group participants the rationale for each recommendation, as well as any preconditions or assumptions that were made in developing the recommendation.

We conducted five focus groups throughout California: three in Southern California, and two in Northern California. In order to gain optimal feedback from different industry perspectives, our focus groups were made up of a variety of market actors. Table 7 shows a disposition of focus group participants. The people who participated in the groups were largely recommended by industry experts we interviewed and also included some of the interviewees. Details on the people who participated in the groups is included in Appendix A.

Table 7. Focus Group Disposition

Group	Market Actors	Participants
Northern California Residential Diagnostic Testing Group	Builders	2
	Contractors (HVAC, lighting)	2
	Researchers	1
	Utility Program Staff	0 (1 no-show)
	Other Program Staff (non-utility)	1
	Title 24 Consultant	1
Northern California Nonresidential Building Commissioning Group	Builders	2
	Contractors (HVAC, controls)	1
	Researchers (LBL)	2
	Architects/Designers	3
	Utility Program Staff	1
Southern California Residential Diagnostic Testing Group	Builders	1
	Contractors (HVAC, lighting)	2
	Engineer	1
	Consultant	1
	City Building Officials	2
Southern California Nonresidential Building Commissioning Group	Builders	1
	Contractors (HVAC, controls)	2
	Researchers	1
	Architects/Designers	2
	Utility Program Staff	2
Insurance/Liability Group[4]	Private Inspectors	3
	Consultants	2
	Builders	1
	Insurance Rep	1

[4] We had initially planned on having two insurance/liability groups – one in Northern and one in Southern California; however on the day of the group in San Francisco, half of the participants cancelled their participation, resulting in the cancellation of the entire group. One-on-one interviews were then scheduled with those willing to participate.

B. Concepts Tested

The following discussion presents specific findings from each of the three focus groups: residential, nonresidential, and insurance/liability.

i. Residential Diagnostic Testing

Based on our literature review and in depth interviews with industry experts, we concluded that there are two main building performance issues that exist from an energy efficiency perspective in the residential new construction arena. While we certainly recognize that these issues may not be the issues that get the most call backs, and they may not be the issues that end up going to court for defects, they are the areas that seem to have the highest energy efficiency implications. These areas are: HVAC installation and design problems and building envelope.

Also, from this background research we concluded that significant gains in energy efficiency can be achieved by improving overall building construction quality and mitigating construction defects through a systems approach to home construction. By "systems approach" we mean a construction process that includes

- A mechanical design of the HVAC system and ducts as part of the initial blueprints, considering house orientation, windows, lighting, and insulation on HVAC loads
- Performance testing of the ducts and HVAC system
- One or more envelope inspections to verify quality of the insulation installation and air and moisture sealing
- Verification and documentation that all building systems perform interactively in accordance with the design documentation and intent, and in accordance with the owner's operational needs

It is this “systems approach” that led to the development of concepts that were tested in the residential focus groups. Table 5 shows the conceptual recommendations that we tested during the residential diagnostic focus groups, along with the rationale behind the formulation of each recommendation, any preconditions or assumptions that must be in place for the recommendation, and whether we viewed the recommendation as a long-, medium-, or short-term solution.

Table 8. Residential Diagnostic Testing Recommendations Tested

Concept/Recommendation	Rationale	Long, medium, short term solution
Require "house as system" approach for all homes built in California. Require mechanical drawings as part of design documents necessary for building permit approval. Require satisfactory inspection results and performance testing reports as precondition for issuing occupancy permit.	Requirement applies uniformly to all projects, maximizes energy efficiency gains if properly enforced.	**SHORT/MEDIUM TERM**
Alternative A**:** Require all builders to hire third party inspectors, at their own expense, to inspect, test, and certify envelope and HVAC systems for **all** homes they build.	This approach provides the most rigorous quality control.	**LONG TERM**
Alternative B**:** Require all builders to hire third party inspectors, at their own expense, to inspect, test, and certify envelope and HVAC systems for a sample of the homes they build.	This approach most closely resembles current Title 24 mechanism.	**LONG TERM**
Alternative C**:** Require certification of HVAC and insulation contractors. Tie the certification to successful completion of training courses. Allow contractors to inspect and test their own installations. Require affidavit from contractors documenting satisfactory inspection results and performance testing reports as precondition for issuing occupancy permit. Establish random third-party inspection mechanism for quality control, with multiple deficiencies being grounds for revoking business license.	This will minimize the costs associated with third party testing and inspections. It will also improve knowledge, skill and ability on the part of contractors. Finally, it will address the concern for project delays due to a lack of performance testing infrastructure. However, it requires significant changes in the enforcement authority of the CEC, the state licensing board, or other agency.	**LONG TERM**
Alternative D**:** Allow contractors to inspect and test their own installations. Require affidavit from contractors documenting satisfactory inspection results and performance testing reports as precondition for issuing occupancy permit.	By relying on the honor system, this eliminates the costs associated with third party testing and inspections and minimizes the concern for project delays. However, it does not assure adequate knowledge, skill and ability on	**LONG TERM**

	the part of contractors. This approach provides the least rigorous quality control.	
Use public goods charge funds to offset costs of contractor and installer training regarding diagnostic testing and revisions to Title 24.	This will improve overall knowledge, skill and ability on the part of contractors	**SHORT/ MEDIUM TERM**
Conduct additional research to quantify potential non-energy benefits of a systems approach to home construction. Quantify the benefits from reduced callbacks and reduced exposure to litigation.	Addresses potential benefits to builders and subcontractors to avoid liability, callbacks and litigation. Additional research may convince insurers to lower insurance premiums for builders and contractors who are diligent in adopting "house as a system" construction practices	**SHORT/ MEDIUM TERM**
Step up consumer education efforts around construction quality issues, particularly in association with ENERGY STAR.	Addresses lack of consumer awareness of the extent of construction defects; addresses potential unwillingness of home buyers to pay for a systems approach to home construction.	**SHORT/ MEDIUM TERM**
Simplify Title 24. Include substantive input from builders and contractors starting in the initial states of revision of the standards	This will encourage wider acceptance of the procedures and reduce the costs associated with the systems approach to home construction.	**SHORT/ MEDIUM TERM**
Offer a state tax credit for Green Buildings.	Addresses added cost issues for building and diagnostic testing.	**MEDIUM/LONG TERM**

a. *Discussion and Results of Residential Conceptual Recommendations*

The following provides feedback heard from the focus groups on each recommendation. This feedback led directly into the formulation of our final recommendations, presented in the Section 5.

Recommendation: Require "house as a system" approach for all homes built in California. Require mechanical drawings as part of design documents required for building permit. Require satisfactory inspection results and performance testing reports as precondition for issuing occupancy permit.

For the most part, participants in both residential groups did not have any problem with the “house as a system” approach. There was particularly overwhelming support for the requirement that mechanical drawings be included from projects’ onset. Participants all agreed that the absence of well-laid mechanical plans prior to construction was the cause of most HVAC construction defect issues (e.g., compromised duct runs and equipment placement).

Alternative A: Require all builders to hire third party inspectors, at their own expense, to inspect, test, and certify envelope and HVAC systems for **all** homes they build.

Recommendation number one, coupled with alternative A, was the least preferred option among participants. They said that no other trades are required to have independent third party inspections and this would be unfair. Experts from the groups felt that requiring all homes to be inspected was unreasonable, and unlikely, given the lack of inspection infrastructure. In addition, requiring all homes to be inspected would only cause project delays. If defects are uncovered, the contractor must be called back to fix the problem, the tester must be called back to reinspect the job, and the process could potentially repeat each time until the problem was resolved. Each call-back represents a time delay and cost.

Alternative B: Require all builders to hire third party inspectors, at their own expense, to inspect, test, and certify envelope and HVAC systems for a sample of the homes they build.

While participants felt having a sample of homes tested was more reasonable than requiring all homes be tested, they were still reluctant to fully support third party inspectors. Again, the lack of available resources (e.g., enough qualified third party inspectors) was cited as the biggest deterrent for outside inspections.

Alternative C: Require certification of HVAC and insulation contractors. Tie the certification to successful completion of training courses. Allow contractors to inspect and test their own installations. Require affidavit from contractors documenting satisfactory inspection results and performance testing reports as precondition for issuing occupancy permit. Establish random third-party inspection mechanism for quality control, with multiple deficiencies being grounds for revoking business license.

For the most part, participants in both residential groups felt this alternative was the best option. Specifically, they felt that the process of becoming a contractor should include a "certification." They claimed that "it's just too easy to become a contractor after a two day seminars-resulting in under-prepared but licensed contractors."

Alternative D: Allow contractors to inspect and test their own installations. Require affidavit from contractors documenting satisfactory inspection results and performance testing reports as precondition for issuing occupancy permit.

This alternative was well-received among participants, however only for the large builders. Several said that they supported a peer review process, where they invite their colleagues to review and/or inspect each other's work. Most were skeptical that the smaller builders could be trusted to check their own work accurately due to lack of personnel and time pressures. There was additional concern that having such an honor system approach to verification was not an effective method of consistent verification and that the process would fall by the wayside once timelines and budgets were tight. Of course it should be noted that those participants who were builders felt that they should be able to be responsible for their own work, likening the process to plumbers, "plumbers don't have to have their work inspected, why should we?"

Recommendation: Use public goods charge funds to offset costs of contractor training regarding diagnostic testing and revisions to Title 24.

This recommendation was very well received by most participants. In fact, using public goods charge funds for training numerous market actor groups was agreed upon unanimously. Participants felt that if diagnostic testing was to be required, using these funds would be a good way to ensure contractors were "all on the same page." In addition, contractors might be more accepting of diagnostic testing as long as they did not have to carry the added burden of cost for training their staff.

In addition to contractor training efforts, there was wide agreement that building inspectors should be brought up to speed with the latest technologies. Too often, according to experts, building inspectors do not understand what they are looking at when it comes to complex mechanical systems. Including them in training efforts would help to ensure that inspections are carried out effectively.

Recommendation: Conduct additional research to quantify potential energy and non-energy benefits of a systems approach to home construction. Quantify the benefits from reduced callbacks and reduced exposure to litigation.

Additional research was supported by all participants, however the definition of what that research should be sparked debate. For the most part, participants felt that more research was needed on issues *not solely* related to energy efficiency or diagnostic testing (such as air quality). In addition, more research was thought to be needed in the area of litigation and quantifying actual losses that result from construction defect litigation. To satisfy the needs and concerns of the insurance providers, these studies should quantify the benefits to actuarial standards so that insurance companies can base premium reductions on the resulting data. This will be difficult, if valuable. Finally, contractors and builders alike mentioned the need for additional research on new materials and installation processes.

Recommendation: Step up consumer education efforts around construction quality issues, particularly in association with ENERGY STAR.

Consumer education was considered to be very important to participants in both of the residential focus groups. As one participant said, "…there is no perceived value with ENERGY STAR …consumers don't ask for it." Participants also felt that in order for them to fully participate in existing ENERGY STAR options, they would need to know that consumers valued it to justify the additional costs. Others pointed out that consumers are not aware of what makes a system "good" or "bad." When a consumer is purchasing a brand new home, they expect they are paying for a "good" system–concern for testing to make sure their systems are working is not considered necessary. Educating consumers on ENERGY STAR and home ratings was seen as a good way to inform them.

Another area of interest among participants was the education of not just consumers, but the industry as a whole. Specifically, inspectors needed some education tools so that they are aware of changes in building practices and materials.

Recommendation: Simplify Title 24. Include substantive input from builders and contractors starting in the initial states of revision of the standards.

This recommendation was considered by all to be the most important. Nearly everyone felt that Title 24 was far too complicated, with too many exceptions, and too many options. In addition, the way Title 24 is worded is confusing and hard to follow, resulting in builders not fully understanding the implications of trade-offs and changes they might make during the construction process (e.g., changing a window size or location). And, while most felt that the code needed to be simplified, they agreed the bar also needs to be raised. Complicated forms, tedious detail, and indecipherable documentation requirements were also cited as rationales for simplifying Title 24.

Recommendation: Offer a state tax credit for Green Buildings.

This recommendation was also favorably regarded. Many thought that the incentive (e.g., tax credit) should be "split" among builders and homeowners, creating the "push-pull" demand mechanism.

ii. Nonresidential Building Commissioning

Based on our literature review and in-depth interviews with industry experts, we concluded that there are two main building performance issues that exist from an energy efficiency perspective in the nonresidential new construction arena, and they are HVAC and lighting controls systems. These seem to be the biggest issues because they are the most complex. They include

1. HVAC installation and design problems

- Equipment sizing and duct sizing--Routinely oversized to compensate for other deficiencies
- Chilled water plants–Performance issues such as interaction of temperature controls on the condenser water, variable speed pump controls, and other components. Systems do not operate efficiently under part-load conditions due to "Delta T Syndrome" when chilled water flow doesn't drop in response to reduction in load.
- Air distribution systems–Biggest source of nonresidential HVAC energy-related issues. Performance issues with variable speed fan controls. Zone temperature controls is an issue because few dual temperature setpoints are properly installed even though they are required. Cooling coils undersized. Sensors on economizers get set improperly.
- Packaged air conditioners–they don't perform efficiently under partial-load conditions. Dampers stick on economizers due to manufacturer defect. Cycling on and off is not an efficient operating mode and energy standards do not require economizers for these systems.

Automatic scheduling and shutoff controls were also mentioned as resulting in performance issues.

2. Lighting Control Systems

- Occupancy sensor controls–lights shut off when space is occupied. Control systems set improperly or are over-ridden by facility managers or occupants who do not understand how to program them.

- Daylighting controls and other lighting controls

We concluded that significant gains in energy efficiency can be achieved by improving overall building construction quality and mitigating construction defects through building commissioning. As there are many definitions of what commissioning implies, we used the following definition of building commissioning.

"Commissioning is a systematic process of assuring by verification and documentation, from the design phase to a minimum of one year after construction, that all building facility systems perform interactively in accordance with the design documentation and intent, and in accordance with the owners operational needs, including preparation of operation personnel." [Bjornskov, et al. ACEEE 1996].

In addition, we consider building commissioning to include the following seven elements:

1. Commissioning plan at the predesign phase
2. Independent commissioning agent from outset
3. Customized test plan as part of project design documents
4. Review systems installation throughout and oversee functional testing
5. Operation and maintenance manuals and plans
6. Training plans
7. Final commissioning report for building owner

This commissioning approach led to the development of concepts that were tested in the nonresidential focus groups. Table 9 shows the conceptual recommendations that were tested during these focus groups, along with the rationale behind the formulation of each recommendation, any preconditions or assumptions that must be in place for the recommendation, and whether we viewed the recommendation as a long-, medium-, or short-term solution.

Table 9. Nonresidential Building Commissioning

Concept/ Recommendation	Rationale	Preconditions/Assumptions, if any	Long, medium, short term solution
Require commissioning for all nonresidential buildings built in California.	Requirement applies uniformly to all projects. Maximizes energy efficiency gains, minimizes construction defects, and thoroughly documents construction process in the event parties involved are subject to a legal challenge	That there is a common and accepted definition of commissioning. There is accepted testing/inspection protocols (whatever is cost-effective). Cost effectiveness has been thoroughly documented; and there is a fully developed infrastructure (qualified agents, adequate training, any/all software that's needed is in place).	**LONG TERM**
Alternative A: Include all seven commissioning elements.	Maximizes energy efficiency gains if uniformly applied		**LONG TERM**
Alternative B: Relax requirement for independent commissioning agent.	Minimizes commissioning costs		**LONG TERM**
Alternative C: Require commissioning only of HVAC and lighting control systems.	Minimizes commissioning costs by focusing attention on systems with greatest performance issues. However, it may not provide necessary quality control to address insurance and litigation issues (fire, sprinklers, elevators, envelope).		**MEDIUM TERM**
Alternative D: Offer compliance credits for commissioning as optional method for complying with Title 24.	Makes commissioning voluntary rather than mandatory.		**SHORT TERM**

Use public goods charge funds to offset costs of commissioning agent training and revisions to Title 24.	This will improve overall knowledge, skill and ability on the part of contractors. It will also improve commissioning infrastructure and expertise, and provide a clear understanding of what building commissioning implies and who the service providers are.		**SHORT/ MEDIUM TERM**
Develop simple and uniform testing protocols.	This will reduce additional project costs, as well as provide standardized methodology and testing procedures that would make the process of commissioning more efficient, cost effective and accessible. It will also minimize extra time and paperwork associated with the commissioning process.		**SHORT/ MEDIUM TERM**

Establish certification process for commissioning agents to make them more reputable and add standardization.	This will create standardized methodology and testing procedures that would make the process of commissioning more efficient, cost effective, and accessible. It will also clear up any misunderstanding about what building commissioning implies and who the service providers are.	That we've been able to come up with a certification process that adds credibility and standardization without becoming over onerous.	**MEDIUM TERM**
Conduct additional studies on costs and benefits for building commissioning, including a quantitative cost-benefit analysis of commissioning relative to energy and "non-energy" benefits, such as improved air quality better work environment resulting in higher productivity.	This will improve awareness of the energy benefits and long term economic savings benefits of commissioning. It will also improve skepticism on the part of building owners and managers that a proposed Energy Conservation Measure is going to work. Provide justification for reduced insurance rates.		**SHORT/ MEDIUM TERM**
Offer a state tax credit for Green Buildings.	Addresses added cost issues for commissioning. Addresses spectrum of owner/occupant concerns (health, safety, productivity, etc)	That we have gained buy-in from a wide range of political interests.	**MEDIUM/LONG TERM**

a. Discussion and Results of Nonresidential Conceptual Recommendations

The following provides feedback heard from the focus groups on each recommendation. This feedback led directly into the formulation of our final recommendations, presented in the following section.

Recommendation: Require commissioning for all nonresidential buildings built in California.

For the most part, participants agreed that commissioning a building was a critical element in good construction practices. However, most agreed that the difficulty with commissioning was that by the time the commissioning agent actually commissions the building (usually at the end of the project), systems are in place, as are "mistakes," and it is then too costly and inefficient to change. Many complained that building owners only ask for minimum code requirements, and thus the only way to get them to pay for or support commissioning is if it is required in the code. In addition, many felt the challenge for commissioning is simply that, "no one wants to hear their building is not working – who would pay for that?"

Another important issue that arose was the awareness that there really is no common or standard definition of what commissioning entails. During the course of these focus groups there was extended debate on the definition of commissioning.

Lastly, participants brought up the point that currently there are no repercussions for buildings that do not pass commissioning. So, from their perspective, commissioning is costly and ineffective if nothing will result from it. That said, most supported the idea that commissioning be required, but also noted the importance of needing a mechanism to ensure the building passed commissioning that problems were addressed.

Alternative A: Include all seven commissioning elements.

While most agreed that all seven elements were important in defining a good commissioning plan, they learned that the end result would be to create an infrastructure of unqualified commissioning agents who "are great at filling out paper, but they won't really understand the complexity of the building and its systems." Those who supported this approach felt that it was "just the stick that was needed to get things moving to build a commissioning infrastructure." However, time associated with completing commissioning that included all seven elements was again raised as an important drawback to requiring commissioning.

Alternative B: Relax requirement for independent commissioning agent

This alternative was more positively regarded among participants since it places responsibility for ensuring proper building operation back on the initial design engineer. There was some concern that, many design engineers are not sufficiently aware of system capabilities. But assuming they could be trained, experts said it should be designers' job to commission their own work.

Alternative C: Require commissioning only of HVAC and lighting control systems

Most agreed that HVAC and lighting controls were the critical areas that needed to have commissioning–-especially considering the complexity of recent systems and technologies. In addition, many said that when a project budget is in jeopardy, HVAC systems are the first to be compromised. That said, overall support still fell on the recommendation to commission the whole building–-but at a minimum, the HVAC and lighting control systems.

Alternative D: Offer compliance credits for commissioning as an optional method for complying with Title 24.

Not one person in either of the nonresidential commissioning groups liked this recommendation. They felt, again, that without repercussions for buildings that do not pass commissioning, "what's the point?"

Recommendation: Use public goods charge funds to offset costs of commissioning agent training and revisions to Title 24.

In general, the recommendation to use public goods charge funds as a means to offset elements of commission was well-regarded. However, most were less concerned with commissioning agent training and more focused on the overall added costs of building commissioning (sometimes as much as 10% of the entire cost of the building). Using the funds to offset commissioning was seen as a better use of those funds. Those who liked the idea of using PGC funds for training felt that architects and designers should also be included since that is generally where the problems arise that result in less-efficient buildings (according to participants). Another potential use of these funds is to sponsor demonstration projects that show the benefits of commissioning, with one participant claiming that "this has worked well in the Northwest."

Recommendation: Develop simple and uniform testing protocols.

Most participants recognized the need for simple and, more importantly, uniform testing protocols. Like the ambiguity expressed as to what commissioning is, testing protocols are likewise seen as inconsistent and lacking in standardization. The best approach to simplification was to address the building by each system. Several pointed out that “simple and uniform” were too vague, especially for the more complex systems. For example, some lighting systems might only require a page of simple protocol, whereas an HVAC system may require more.

Recommendation: Establish certification process for commissioning agents to make them more reputable and add standardization.

This recommendation was thought to be one of the better ones in the nonresidential commissioning groups. While several reminded us that the California Energy Commission does not have the authority to certify contractors, per se, other organizations, such as ASHRAE do. In addition, it is important to ensure that the certification, regardless of what it ultimately becomes, has a level of value to the contractor or energy engineer. It has to be considered to be worthwhile for them to pursue certification. Most agreed that part of the certification process would need to focus on training, especially for highly technical systems, so that commissioners did not simply become “paper pushers.”

Recommendation: Conduct additional studies on costs and benefits for building commissioning, including a quantitative cost-benefit analysis of commissioning relative to energy and “non-energy” benefits, such as improved air quality and better work environment resulting in higher productivity.

Like the residential participants, most agreed that conducting additional analysis on costs/benefits of commissioning was an important step in learning which systems are most likely to require testing and which offer the most potential savings. In addition, other studies that present successful cases of commissioning were seen as a useful tool for builders to share with building owners, illustrating to them why commissioning is important.

Recommendation: Offer a state tax credit for Green Buildings.

This recommendation was generally thought of as a good idea among focus group participants. Several thought that labeling a building “green” carried value for building owners and tenants. Moreover, like the residential recommendation, participants felt that splitting the incentive between builders and owners might incent the owner to care more about energy efficiency, even though traditionally they are not the direct beneficiaries of such measures.

iii. Insurance and Liability Discussion

Our approach to the insurance and liability focus group was much more exploratory in nature. Throughout the literature review and in-depth interviews it became increasing clear that not much information exists regarding the insurance industry, construction defects, and the implications on energy efficiency. As such, we spent most of the time during the focus group trying to identify the links between better construction quality and insurance liability. Much of what was heard supports the recommendations tested in both the residential and nonresidential groups. The following presents highlights from the focus group.

Participants were first asked to describe the role of construction defect litigation in driving insurance rates. Not surprisingly, everyone agreed that poor construction led to higher insurance rates. And, those who worked with residential builders said that obtaining insurance policies was a "real headache." Several likened the process to applying for a job–-they have to jump through all kinds of hoops to get insurance. Others noted that many companies have been formed as a direct result of construction litigation (e.g., Pacific Property Consultants) in order to reduce the likelihood that developers will be sued.

For the most part, participants agreed that condominiums posed the largest problems for defect litigation, especially in San Diego. All agreed that San Diego was the "hot bed" for construction litigation–mostly as a result of water intrusion. Several said that because of this, developers are staying away from building condominiums, and instead are focusing on single-family detached homes, claiming that, "as a builder, single-family homes are much safer to build due to the reduced likelihood of litigation."

Everyone in this group said that the relationship between the builder and the insurance company was a critical component in avoiding litigation. Paper trails must be thorough and everything must be documented in order to prevent law suits. In addition, having the paperwork to back up and justify construction practices seems to alleviate some risk from the perspective of the insurer.

The next part of the discussion focused more on what insurance companies were doing about litigation issues. Overall, participants felt that insurance companies were becoming much more involved in the process–-hiring their own inspectors to conduct diagnostic testing. Some said that insurance agents are actually coming out to the job site and monitoring what is being done so that they have a paper trail to document quality. Many of the larger builders seem to be using third party inspectors primarily, as a result of being sued frequently.

One problem participants mentioned was that formerly only the builder would be sued. Now, however, everyone who is involved in a project is sued (e.g., all subcontractors). In addition, if a suit is initiated because of water intrusion and an inspector is sent out to document the damage, they then explore the entire house. Many other problems that may not have caused the occupant any distress may then be added to the suit. It is believed that most cases never make it to court because it costs more for a trial then it does to settle. As a result, participants believed that litigation was on the rise because it is "so easy to sue someone these days."

For the most part, design deficiencies and substandard or poor workmanship were cited as the top two causes of sparking construction defect litigation Water intrusion is the single defect that leads to most litigation.

Participants were then asked how feasible they thought it was to develop a standardized testing program that could catch most construction defects. Everyone in the group thought that this was a great idea, and quite feasible. However, they noted the difficulty in reaching consensus on what "standardized" should mean. Most also felt that insurers would have a vested interest in helping develop these standards and should therefore be part of the process.

5 RECOMMENDATIONS

Based on the results of the literature review, the interviews, and the focus groups we developed a refined list of recommendations. The recommendations presented here reflect the opinions of the people who participated in the focus groups and the comments received from reviewers of those results, including members of the Codes and Standards Statewide Committee and the CEC. A number of these recommendations are already being worked on by the utilities, the CEC and others.

Developing these recommendations in consultation with leading edge market actors with direct experience and insight into the building performance issues that we identified, rather than a random sample of actors, raised two concerns. First, these people are not completely representative of their respective groups. The majority of builders, inspectors, etc. are not yet sensitized to these issues or potential solutions. Using our "experienced" group, we could jump right into developing strategies to improve measure effectiveness and the code process, rather than spending time educating people and then obtaining their first thoughts about it. Second, the recommendations would reflect their biases rather than providing ideas that are truly valuable and viable to the community. We attempted to prevent this from happening by using the focus groups, which each consisted of different market actors, to develop consensus strategies. The recommendations here are only those that reflected collective thinking. Please note that there may be other viable options not identified here.

We recognize that there are still challenges, in some cases considerable challenges, to implementing the recommendations. The wording of these recommendations and the caveats noted address these challenges and capture the comments of the participants and the reviewers. Several challenges noted apply to many of the recommendations in both the residential and nonresidential markets. These include:

Increased building costs are always problematic to the construction industry. Nevertheless, many improvements in construction effectiveness promise to result in reduced building owning and operating costs, at least after the industry transitions to new practices. The utilities, the CEC, and organizations such as CBIA, need to consider how to enact recommendations that achieve improved energy efficiency objectives in a manner that mitigates potential increased first costs.

The recommendations may be more burdensome to smaller and custom builders. Larger builders have a larger base across which to spread the costs of training and testing.

Procurement of long-term funding for some of the recommendations will be important. While PGC funds are recommended to "kickstart" some of these actions, they are not expected to remain permanently available. To become sustainable, the activities will either need another funding source, be government-mandated with the cost borne by builders or owners, or the market place will encourage their inclusion into the standard building process.

A number of the recommendations cannot be implemented solely by the utilities. They will require non-utility proponents to champion them into practice.

A. Residential Recommendations

The following final recommendations stem from results of the literature review, interviews, residential diagnostic focus groups, and subsequent reviewer comments.

1. Require mechanical drawings as part of design documents for building permits.

Clearly there is a need to include mechanical drawings early on in the construction process. We heard this in nearly every in-person interview as well as in both the residential focus groups. The underlying issue is that without including them, changes in the overall blue prints are made without consideration for mechanical systems, thus jeopardizing the quality of installation. Often when mechanical designs are not included early in the process, the quality of duct installations in particular suffers. Due to lack of space, ducts are often sized smaller than necessary to fit in tight spaces thus constricting air flow, and sometimes completely cutting it off. Furthermore, in the hyper cost-conscious construction industry, the last systems to be installed are often compromised, substituting lower quality materials, resulting in a system that does not perform as designed. The impact of such issues on efficiency and performance can be decreased by requiring mechanical drawings—indicated equipment placement, duct runs, and duct sizing from the onset. Requiring design drawings is an important step toward having contractors complete Manual J and D for each house plan.

Caveats to Recommendation 1: The goal of this recommendation is to foster continuity from design through construction. While requiring mechanical drawings is widely expected to improve HVAC and duct performance, it is no guarantee of quality workmanship. Thus, without field verification, it cannot increase measure effectiveness. It is also recognized that drawings reflect pre-construction thinking. Design elements are often modified during construction to minimize cost or to handle the unexpected site glitches. Title 24 already encourages this, in a way. Bill Pennington of the CEC alerted us that field verification to demonstrate implementation as designed is already included in Title 24 compliance credits. It is also part of Building Industry Institute (BII) training, and the ComfortWise program, showing that there is a precedent for implementing this recommendation. Still, prior to implementing this recommendation, a decision must be made as to whether this would be mandated at the state or at the local level. If at the state level, we were told that a new statute to give the CEC this authority would be required. Finally, an undercurrent to almost all of these recommendations is that they might prove especially burdensome to smaller builders. Drawings generally cost about $500 per design.

2. Require certification of HVAC and insulation contractors and installers. Tie the certification to successful completion of training courses. Require an affidavit from contractors documenting satisfactory self-inspection results and performance testing reports as precondition for issuing occupancy permit.

Certification was heralded as an important component of improving HVAC and insulation effectiveness. The importance of including both contractors and the actual installers in the certification was noted so that the certification would be more meaningful. While we realize the CEC does not have the authority to "certify" HVAC and insulation contractors, teaming with or encouraging professional organizations such as ASHRAE to certify them is highly recommended. According to our focus group respondents, there are still many contractors who operate simply by rule of thumb and by "we've always done it this way" thinking despite improved technologies and installation practices. By requiring such certification, contractors might be able to see the benefits that new practices offer (i.e., not only in performance, but also in reducing installation costs), and decide on their own that they will change. In regards to developing appropriate training mechanisms, it was pointed out that several organizations, including the North American Technician Excellence (NATE), already provide diagnostic testing training or certification courses and that there is opportunity for utilities to boost these efforts, rather than create something new.

One of the more surprising findings was that most of the respondents in the focus groups supported the idea of self-inspection, and were, in general, much more trusting of each other than previous studies have shown. The concept of self-inspection, as certified contractors, will alleviate any added costs of hiring a third-party inspector. Furthermore, avoiding third-party inspection requirements—indicating a level of trust in the industry—might also decrease the often negative and adversarial attitude many builders have toward government regulators and energy efficiency programs.

Caveats to Recommendation 2: Several items clearly need to be addressed to implement this recommendation. One is to determine how certification relates to current contractor licensing. Another is procurement of long-term funding to cover the costs of the certification program. Implicit in this recommendation is the use of existing PGC funds to partially or fully offset the cost of setting up the training and certification. There is precedence for using PGC funds for this purpose. Since that funding is not expected to last in perpetuity, however, other mechanisms need to be explored to sustain the activity. The utility and CEC already have some contact with professional organizations that could provide training and certification; in particular, Charles Segerstrom at PG&E and Jeff Johnson at New Buildings Institute indicated familiarity with possible avenues for residential contractor/installer training. Finally, in order to really work, someone (or some organization) will have to champion it. PGC-funded programs can play a role here.

3. Establish mechanisms to conduct random, third-party inspections for quality control.

These inspections would be conducted by people who are not local building inspectors. The inspections would cover a sample of homes constructed by each builder. CBIA strongly supports the concept of independent, third-party inspections and using a sampling approach to control costs. Sampling is also a feature of EPA's ENERGY STAR Homes program.

Having third-party random inspections was one of the more controversial aspects of our interviews and focus group discussions. Most of the non-field representatives felt this was necessary; there were also several contractors who felt that they already used third-party inspections. In addition, all of the insurance focus group representatives said they had to use third-party inspectors simply to protect them from litigation. The skepticism, however, was primarily among the larger builders speaking about the smaller contractors and custom builders. The larger builders, who were the only ones represented in the focus groups, said that shoddy construction practices are associated with smaller builders and contractors, and the only way to "keep them honest" is to make them pay for random third-party inspections.

Caveats to Recommendation 3: Being one of the more controversial results, it was no surprise that this recommendation is surrounded by a large number of concerns. Before this recommendation can be implemented, quite a number of issues need to be resolved, such as: to whom will the third-party inspectors report? The effectiveness of this recommendation will rest on how these inspection results are used. One suggestion is to use an approach similar to that used by CHEERS. This would put the authority with the local building department, who would oversee but not conduct the inspections. Given that the inspections will be made on only a sample of the homes, there are several considerations the implementors need to address regarding the sampling. How will the homes be chosen? Will the homes all need to be inspected at the same stage of construction? If not, will there be designated acceptable stages in the construction process at which inspections must be conducted? The sampling issue is already under investigation. For example, the ComfortWise program is using a sampling approach. Regarding the timing of testing, this was apparently discussed at length in the adoption of compliance credits for the 1998 standards, and is being addressed through CHEERS and ComfortWise's implementation of the credits and ENERGY STAR Homes qualification. This is also being considered in the PIER-funded Residential Commissioning project that LBL is leading and that includes representatives of CEC and utilities. Finally, since inspections will cost money, a long-term funding mechanism must be developed to ensure the sustainability of this practice. Again, PGC funds could be used to create the third-party inspection guidelines, train the inspectors, and initially pay for the inspections, but this is not a permanent solution. At this time, it is unclear whether this could become a self-sustaining market-based change or whether a long-term funding mechanism will be necessary to ensure the sustainability of this practice.

4. Use PGC funds to conduct contractor and installer training on proper installation, proper testing, and recent changes to Title 24.

Nearly everyone during the data collection process felt that a good use of PGC funds would be to conduct specific contractor training on proper installation, testing, and recent changes to Title 24. While there were several suggestions as to how to best communicate this information to busy contractors, most supported the idea, for example, of on-site hands-on exhibitions during construction, or demonstrations of proper installation. Respondents agreed that while such programs would be expensive, they would be effective in educating contractors. In addition, by going to the job site, one can target the installers, not just the contractors who employ them. Lastly, there was discussion about if and how changes in Title 24 are communicated to field staff—most felt they are not communicated well. Thus, using PGC funds to create better mechanisms to take the message directly to field staff could be a good idea. Several suggestions that were mentioned included providing a special section on the CEC website that provides a quick overview of the Title

24 changes, in an easy–to-read format, using simple and clear verbiage. Another suggestion was to produce a newsletter that includes recent changes.

Caveats to Recommendation 4: This recommendation is already a work-in-progress. The utilities have a number of training sessions available to members of the building industry—including Title 24 consultants, local building officials, HVAC contractors and installers, architects, mechanical engineers, equipment suppliers, developers, and Realtors. A list of these training sessions is included in Volume II, Appendix E of this report. Despite offering training at alternative locations and times, the utilities find they are not always successful at persuading the intended market actors to attend the training sessions. Conducting training sessions at the construction site may address this barrier.

5. Use PGC funds to augment and train local building inspectors on the "house as a system" approach.

This recommendation stems from the concern that energy-inefficient construction is as much due to under-skilled building inspectors as to builders and contractors. Many of those interviewed felt that the local building inspectors are not up to date on the new energy-efficient technologies, and do not understand the interactive nature of a home's component systems and the implications of the poor performance of any one component on the others. Moreover, it was felt that few inspectors take the time to keep abreast of the latest standards and technologies so the overall pool of qualified inspectors needs to be increased. One approach to this training would be similar to the proposed contractor training. Having inspectors trained at actual homes would be an effective way to deliver training on diagnostics and quality construction results.

Comments on this recommendation were all favorable, both during the focus groups and in subsequent review. Reviewers thought that having building inspectors trained on the "house as a system" approach would enhance compliance. Most, but not all, agreed that having more trained inspectors would be beneficial in decreasing potential construction delays that could arise from inspectors being unfamiliar with the methods.

Caveats to Recommendation 5: Barriers go far beyond the need for training and are more related to lack of local government budget resources, low priority of energy efficiency relative to health and safety code requirements, and lack of educational and professional expertise. Implementing this recommendation will require the utilities to enlist the support of and collaborate with several parties. Partnerships with professionals who can provide the training will be necessary. Interactions to gain the support of local building officials will be necessary. Finally, this will likely need a non-utility champion to make it happen.

6. Conduct additional research to quantify potential non-energy benefits of a systems approach to home construction. Quantify the benefits from reduced callbacks and reduced exposure to litigation.

Throughout our study it has become clear that an area in need of additional research is insurance and liability. Conducting a study that investigates actual claims related to construction defect litigation would help indicate the potential value for linking building quality and avoided litigation costs. To date, we have heard of only one such study, and have yet to learn who performed it. One suggestion is to work directly with the insurance industry, perhaps by co-sponsoring a study, to identify the impacts of construction quality on their industry. Most of the insurance representatives we spoke with during our in-depth interviews indicated that this is currently a “hot issue” at industry conferences, and that now would be a great time to initiate such a study.

Caveats to Recommendation 6: We need to emphasize that the litigation referred to is rarely, if ever, due to energy efficiency performance failures and energy standards cannot be used to enforce construction quality. Nonetheless, we are already seeing a convergence of interests here that reinforce the value of conducting energy efficiency measure benefit assessments. The AAMA has been working with window manufacturers because of leakage litigation problems, offering an opportunity to also discuss improving energy efficiency through better construction and installation of window units. Also, the Building Industry Institute has been successful in associating improved quality in energy efficient construction with reduced builder exposure to liability. Finally, it should be noted that quantifying non-energy benefits of building energy efficiency improvements in ways that are meaningful and actionable for the insurance industry may be difficult to accomplish.

7. Increase consumer education on energy efficiency by way of a mass media public awareness campaign.

There was quite a bit of debate during data collection efforts regarding the role of consumer demand in driving the marketplace toward higher efficiency and quality construction. Tradesmen felt that consumers have not attached a value to energy efficiency, and therefore do not care about it—thus providing builders little incentive to spend resources improving a home’s efficiency. However, they also thought that the reason consumers do not care about energy efficiency is because they do not know what makes a house efficient nor how this impacts the homeowner’s expenses. By increasing consumer education and creating value for quality construction and energy efficiency, builders and contractors alike believe consumers will begin asking for more efficient homes.

Caveats to Recommendation 7: The utilities already have some energy efficiency consumer awareness programs in place. To help builders see the value of energy efficiency, these programs could be more focused on identifying and educating consumers about a few specific measures that they should look for in a new home. This might prompt consumers to start asking for energy efficiency measures and related quality construction.

8. Establish simple, standardized diagnostic testing procedures.

While nearly everyone agreed that diagnostic testing procedures should be required, the dilemma is with how to define such procedures. There are many different ways of testing a home, and not everyone agrees which test is the best indicator of a home's performance. By establishing common protocols in the standards, everyone will have access to information on how to conduct diagnostic testing.

Caveats to Recommendation 8: This has already been accomplished for duct testing. That standard is the Duct Blaster test, performed by sealing all the ducts and pressurizing to a standard level (usually 25 Pa). The Duct Blaster provides a method for determining flow based on how hard the Duct Blaster fan is working to achieve the required duct pressure. This type of standardization needs to be extended to other HVAC components and the building envelope. PGC funds could perhaps be used to facilitate this extension.

9. Simplify Title 24 while raising the standards (i.e., make them more stringent but easier to understand and apply).

Title 24 is believed to be far too complicated and hard to understand. As one focus group respondent said, "…the Codes and Standards are written like encyclopedias—and we expect users to memorize them." Simplifying the standards would reduce confusion and improve the likelihood of compliance. Simplification could include two types of changes: word changes (e.g., use "windows" instead of "fenestration") and elimination of minor requirements (e.g., requiring R19 insulation for one home orientation and R22 for a different orientation). In addition, higher or more stringent standards should be required, such as offering fewer credits for easy trade-offs such as installing window shading. Using the previous example, perhaps all orientations of the same home would require R22 insulation. Many respondents complained that contractors and builders opt for the easiest credits, even if they doubt their effectiveness, and therefore sacrifice energy efficiency.

Caveats to Recommendation 9: There was considerable concurrence on this recommendation, despite the potential restrictiveness of it. In the focus groups, (large) builder representatives said they expect there would be support among builders for simpler requirements even if they are more stringent. CBIA, which might be more widely representative of builder views, supports the mandate that any update to Title 24 must be cost-effective in its entirety when compared with historical practice. To implement this recommendation, it is evident that representatives from many groups will have to grapple with the trade-off between the increased compliance that simplicity would facilitate and the additional costs that increased stringency would likely impose. The "devil is in the details" adage seems applicable here. Thus, this could be a long time in coming.

10. Offer state tax credit for "green" (and tested) energy-efficient buildings to both builders and consumers.

By offering a state tax credit for "green" (and tested) energy-efficient buildings, market actors are being encouraged to pursue field-verified energy efficiency. Respondents believed that this might be more successful if associated with construction of "green" buildings. By splitting the incentive, so that both owners and builders receive a portion of the tax credit, it would ideally create a symbiotic push-pull approach to market transformation. Obviously, the infrastructure would need to be in place to support the tax credit, as well as governmental buy-in. Everyone who reviewed this recommendation thought it would be helpful for promoting energy efficiency.

Caveats to Recommendation 10: This is clearly a recommendation that utilities cannot implement on their own. It will need a champion within the legislative process.

B. Nonresidential Recommendations

Seven final recommendations are presented here, based on results from the literature review, interviews, nonresidential building commissioning focus groups, and subsequent reviewer comments. Of these, most are analogous to the recommendations made for residential construction. There are, however, several differences worth pointing out. First is the recommendation of mandatory testing for nonresidential construction. Second is the absence of requiring third-party inspectors. Third is a provision that could prove especially helpful to smaller building owner/developers or potential commissioning agents: an equipment lending library. Finally, there were no recommendations to simplify and increase the stringency of the standards.

1. Require commissioning of the HVAC system and lighting controls with the mechanical engineer of record responsible for the HVAC system and the architect responsible for the lighting.

This recommendation represents feedback that we heard from the respondents in both the in-depth interviews and the focus groups. The systems most at risk for construction defect in new nonresidential buildings are the HVAC and the lighting controls systems. While architects and builders alike might be reluctant to commission the whole building due to cost and time constraints, these two systems in particular should addressed. In addition, because there are so many market actors involved from design to inspection, it is difficult to accurately determine who is at fault for poorly installed systems. Since the mechanical engineer is responsible for designing the HVAC system, it seems most appropriate assign responsibility to this party for ensuring that this system operates as designed. With respect to lighting controls, architects or lighting designers should see that lighting and the control systems are installed and function as initially planned. In particular, since occupants can and do override controls when the lights do not perform as needed, the lighting designer needs to ensure that the controls are appropriately installed and calibrated. That is, the lighting designer needs to stay involved throughout the construction process.

There is precedent for this recommendation in requirements Massachusetts put into effect in January 2000. These require the lighting engineer and engineer of record to document how the lighting and HVAC systems are supposed to operate and certify that the design intent has been implemented. Other areas, such as the City of Seattle, have written plan and design intent requirements.

Caveats to Recommendation 1: The biggest problem with implementation of this recommendation may be how to overcome the cost burden that this will impose on builders. Full building commissioning costs can be 10-20% of the construction cost of a building. Also, a commissioning infrastructure needs to be developed in California, including training for lighting designers and mechanical engineers on commissioning procedures. Public electricity charge funding is being used in the Pacific Northwest, New York, and other northeast states to develop a commissioning infrastructure in those parts of the country. PGC funds could be used to develop this infrastructure in California.

2. Use PGC funds to offset costs of commissioning.

Our interviewees and focus group participants were very concerned about the cost of requiring commissioning. Building owners and developers often see commissioning as a discretionary cost that could lead to construction of the building going over the budget and eating up profits. Commissioning can be one of the first things to go when construction budgets get over-extended. By using PGC funds to offset the costs of commissioning, the likelihood of having commissioning cut from the plans could be alleviated.

Caveats to Recommendation 2: It is not anticipated that PGC funds will be available to cover the entire cost of commissioning or that they will be available indefinitely. Since building commissioning includes drafting written plans, conducting testing, and fixing mistakes, its unclear whether PGC funds should be applied to all or only some components of commissioning.

3. Design simple and uniform testing protocols.

Not unlike the residential diagnostic testing protocols, commissioning implies many things to many people. As such, having simple and uniform testing protocols would alleviate confusion regarding what constitutes the commissioning process. Some headway has been made in addressing this: ASHRAE has a committee on testing protocols. More locally, PG&E is developing testing guidelines.

Caveats to Recommendation 3: This recommendation will require collaboration between commissioning experts developing the guidelines and the professionals that will be trained to use them. Furthermore, while utilities can and are encouraging uniform protocols, they cannot impose them.

4. Use PGC funding to establish a standardized certification process to train and certify commissioning agents.

This recommendation directly addresses several of the commonly cited barriers to building commissioning: cost, lack of awareness of pervasive equipment performance problems, and lack of knowledge on how to perform testing. According to our focus group respondents, there are still many contractors who operate simply by rule of thumb and by “we’ve always done it this way” thinking despite improved technologies and installation practices. By requiring training and certification, professional commissioning agents would be able to see the benefits that commissioning offers, understand commissioning practices, and demonstrate their competency in applying the procedures.

Caveats to Recommendation 4: We realize the CEC does not currently have the authority to “certify” commissioning agents. Teaming with or encouraging professional organizations such as

ASHRAE or the Building Commissioning Association to certify them was seen by project participants as viable and highly recommended. Developing and sustaining this infrastructure component will likely require continued funding over the medium to long term.

5. Use PGC funds to create a library of testing equipment for builders and their commissioning agents to borrow.

This recommendation stems from feedback we received about the lack of ownership of equipment for testing building systems. Such equipment is often too expensive for a building owner/developer or potential commissioning agent to acquire for infrequent use. Activity is already underway on this recommendation. The Pacific Energy Center has started an equipment lending library. Increased access to testing equipment is part of the infrastructure needed for some of the other recommendations to be effective.

Caveats to Recommendation 5: The issues that need to be addressed for this recommendation include identifying which equipment to make available and establishing the locations from which the equipment might be obtained.

6. Use PGC funds to conduct additional studies on costs and benefits of building commissioning, including a quantitative cost-benefit analysis of commissioning relative to energy and non-energy benefits, such as improved air quality and better work environment resulting in higher productivity.

Suggestions for additional studies of the nonresidential sector primarily focus on generating and communicating findings from successful building commissioning demonstration projects. Many builders said that having such studies available would help them sell commissioning to building owners and justify allocating part of the project's budget to commissioning.

Caveats to Recommendation 6: This recommendation is similar to that made for residential construction. Again, the litigation referred to is rarely, if ever, due to energy efficiency performance failures and energy standards cannot be used to enforce construction quality. Nonetheless, a convergence of interests reinforce the value of conducting energy efficiency measure benefit assessments. The AAMA has been working with window manufacturers because of leakage litigation problems, offering an opportunity to also discuss improving energy efficiency through better construction and installation of window units. Obtaining meaningful and actionable results from these studies will likely be difficult and costly.

7. Offer state tax credits to builders and building owners for commissioning energy-efficient and green buildings.

Like the residential market, offering a state tax credit for “green” and energy-efficient, tested buildings, market actors are being encouraged to promote energy efficiency. In addition, by extending this to a split incentive, whereby owners and builders both receive the tax credit, it would ideally create a symbiotic push-pull relationship, leading to market growth and, ultimately, market transformation. Appropriate infrastructure, as well as governmental approval, would need to be in place to support this growth. Suggestions were made that perhaps calling this an “energy credit” but leaving a loose connection with so-called green buildings could make this appealing to people who could be instrumental in enacting it.

Caveats to Recommendation 7: This is clearly a recommendation that utilities cannot implement on their own. It will need a champion within the legislative process.

C. Recommendations for Future Research

Implementation of some of the recommendations made here will require or would greatly benefit from additional research. These items include:

- Conduct studies that assess and document the energy as well as non-energy benefits of diagnostic testing and/or building commissioning to market actors, including insurers, builders, and owners/buyers. These should be actuarial quality studies that would afford insurers confidence to reduce builders’ premiums. We were told that a study attempting to do this was started by Heshong Mahone Group in 1992 but was not completed. It was suggested that a first step would be to select a specific focus or prioritized list as part of any benefits assessment research.
- Actively foster partnerships with professional associations in the construction industry to facilitate development and implementation of training and certification for diagnostic testing and building commissioning.
- Determine exactly how requirements of Title 24 (current and proposed) overlap with activities that comprise building commissioning. This may involve revisiting and/or revising the working definition of building commissioning for best use in California.
- Track how building commissioning in Massachusetts is working to gauge the likely practicability and benefit of the first nonresidential recommendation above. Information about the Massachusetts code can be accessed through the state’s website at http://www.state.ma.us/bbrs/chapter13.htm.

- Since there is still some controversy regarding the use of third-party inspections in residential construction, conduct a study to investigate their need/acceptance and develop practical strategies for using them.
- The recommendations above are somewhat general. Further investigation needs to be made into which residential and nonresidential submarkets of the construction industry will be the best hosts for these recommendations. Utility/PGC-funded programs should be directed at implementing the recommendations in these markets first.

MA&E Study in Support of Codes & Standards

FINAL REPORT
Volume II: Appendices

PG&E Study ID number: 411

August 31, 2000

Measurement and Evaluation
Customer Energy Efficiency Policy & Evaluation Section
Pacific Gas and Electric Company
San Francisco, California

Market Assessment & Evaluation Study in Support of Codes and Standards

Final Report
Volume II: Appendices

A Joint Study by Pacific Gas & Electric, San Diego Gas & Electric, Southern California Edison, Southern California Gas, and the California Energy Commission

Statewide Project Manager: Mary G. Dimit, PG&E

Project Advisor: William Pennington, CEC

Prepared by
Pacific Consulting Services
1320 Solano Avenue, Suite 203
Albany, CA 94706
510/526-3123

Davis Energy Group
123 C Street
Davis, CA 95616

Eley Associates
142 Minna Street, 2nd Floor
San Francisco, CA 94105

August 31, 2000

TABLE OF CONTENTS

Volume II: Appendices

A. INDUSTRY EXPERTS AND UTILITY STAFF INTERVIEWED AND FOCUS GROUP PARTICIPANTS RECRUITED

INDUSTRY EXPERTS AND UTILITY STAFF INTERVIEWED

Last Name	*First Name*	*Affiliation*	*Market Role*	*Modules Completed*
Aquirre	John	Loanz.com	expert in residential energy eficient financing programs	D
Barrows	CeCe	Pacific Gas & Electric, Comfort Home Program		A, B
Baylon	David	Ecotope	Evaluated NW energy code implementation	A, B
Beaman	Doug		diagnostician, diagnostics trainer for PG&E, SoCalGas	B
Blaine	Briane	California Pacific Homes	major builder participant in City of Irvine's IQ+ program	A
Carlton	Phil	CHEERS	Training & QA Coordinator	A, D
Chamberlain	Bruce	San Francisco Bureau of Energy Conservation	7th national Building Commissioning Conference attendee	C
Chao	Mark	Institute for Market Transformation	expert on commercial property valuation related to energy efficiency and building commissioning	B, F, E
Corson	Craig	Glumac International, Inc.	large mechanical engineering firm, attendee 7th national Building Commissioning Conference	C
Doyle	John	Building Commissioning Association		B
Elberling	Lance	PG&E	Member Residential commissioning Advisory Group	H, I
Felts	Don		expert on problems and commissioning of rooftop HVAC units	A, C
Fernstrom	Gary	PG&E		G, I
Fraser	Becky	City of Yuba City	building officials receiving CEC effective enforcement award	A
Grimm	Bill	SCE		H
Guisasola	Pete	City of Rocklin building official	past president of California Building Officials	A, B
Gustavson	Dale	Energy &Environment Management Magazine	Editor, 7th national Building Commissioning Conference attendee	C
Haggert	Greg	ABB, Energy Capital		D
Hammon	Rob	ComfortWise	Energy consultant to California Building Industry Association, trainer for DOE/CEC/building industry grant to train production builders on Title 24 and diagnostic testing, author of duct efficiency/duct protocol report, Comfortwise (third party utility program aimed at quality constructed residences that meet Energy Star), co-developer of San Diego green building program, liability insurance connection	A, B, E
Harrold	Mark	City of Temecula	plan checker/inspector, CEC awards for effective enforcement	B

Last Name	*First Name*	*Affiliation*	*Market Role*	*Modules Completed*
Higgs	Harvey	City of Benicia	building officials receiving CEC effective enforcement award	A
Hoyt	Steve	Local Government Commission	project manager for LGC's third party program and report	I
Hunt	Marshall	PG&E	energy consultant, PG&E liaison to Title 24 building standards	G, H, I
Johnson	Jim		building inspector, CEC award for excellent enforcement	B
Johnson	Jan	SCE		G, H, I
Kaufmann	John	Oregon Office of Energy	Commissioning Program Manager	C
Kello	Mazin	SMUD	Manager of Nonresidential Commissioning Program	C
Knight	Dennis	Oregon Office of Energy	Energy-efficient loan program	D
Kunkle	Rick	Washington State University	Involved in the Washington nonresidential energy code simplification process	A, C
Long	Marion	City of Anaheim Public Utilities Department		A
Madlin	Cathy	Madlin's Enterprises	energy consultant, building official trainer, building department contract plan checker for several jurisdictions	A, B
Mary	Tucker	City of San Jose Dept. of Environmental Services	Contact for Green Building program	F
Mattinson	Bill	Sol Data Energy Consulting	large Title 24 energy consulting firm, California Association of Building Energy Consultants liaison to Energy Commission, compliance reviewer for PG&E new construction programs	H
McClintock	Larry	City of Madera	building officials receiving CEC effective enforcement award	A
Mills	Evan	Lawrence Berkeley Lab	expert on relationship of energy efficiency to international insurance providers	E
Modera	Mark		expert on need for diagnostic testing of ducts in residences and commercial buildings, co-author of report of duct efficiency, field researcher on duct efficiency in California	A, B, C
Munves	Susan	City of Santa Monica	Environmental Resources Manager, local government program pursuing beyond T-24 buildings	F
Nelson	Bruce	State of Minnesota Department of Public Services	developer of the Minnesota state energy code which includes diagnostic testing requirements for residences	A, B
Nittler	Ken	Enercomp/Westlab	standards compliance software developer, energy consultant, activist in Title 24 standards program, model energy code hearings, National Fenestration Rating Council	B
Owens	Meredith	City of Alameda, Bureau of Electricity		A
Parker	Gretchen Ann	Institute for Market Transformation	7th national Building Commissioning Conference attendee	C, D, E
Pennington	Bill	CEC		G

Last Name	***First Name***	***Affiliation***	***Market Role***	***Modules Completed***
Petersilia	Pat	Southern California Gas Company	participating with the CEC in redesign of SoCalGas' residential new construction program to promote compliance with T-24 through the duct design and sealing compliance options and to promote Energy Star using CHEERS for field verification	G, H, I
Phillips	Tom	California Air Resources Board	indoor air quality expert, green buildings programs	A
Pierce	Tony	SCE		G, H, I
Piette	Mary Ann	Lawrence Berkeley Lab	nonresidential building commissioning expert	C
Scott	Robert	California Home Energy Efficiency Rating System (CHEERS)	Technical Director	B
Segerstrom	Charles	PG&E	Director of the Stockton Training Center - PG&E's diagnostic training center, familiar with state and national new construction, diagnostic testing, and contractor performance verification programs	A, B, D
Sherman	Max	Lawrence Berkeley Lab	ventilation, indoor air quality and duct system expert, residential building commissioning project, duct efficiency report co-author	A, B
Stackhouse	Robert	CertainTeed Corporation	program manager for Certified Plus Home Program that uses dianostic testing to verify quality construction and to guarantee energy bills, currently starting pilot program in Fresno, CA	A, D
Stevenson	Eric Olson & Mi	MJB	enthusiastic HVAC Contractor	A
Tabor	Steve	Princeton Energy Programme	architect of energy efficient commercial buildings, chairman of CBEE technical advisory group, designer of PG&E Act2 super-energy efficient building, former chairman of CEC Professional Advisory Group for nonresidential Title 24 standards	D
Thomas	Michelle	Southern California Edison Company	Comfort Wise Program	G, H, I
Thompson	Larry		Architect, working with City of Santa Barbara to develop green buildings program, previously developed design assistance program	F
Weitz	David	MA Board of Building Regs & Standards	Energy Code Coordinator	B, C
Wiesner	Rick	Sacramento Municipal Utility District	Residential and nonresidential new construction program manager	A, B
Wylie	Rick	Beutler heating & Air Conditioning	largest new constuction res. HVAC Contractor	A

FOCUS GROUP PARTICIPANTS RECRUITED

NORTHERN CALIFORNIA

Sacramento - Residential Diagnostic Testing Group, June 2, 6:00 PM		
Last Name	**First Name**	**Affiliation**
Wray	Craig	Lawrence Berkeley Lab
Hammon	Rob	ComfortWise
Wylie	Rick	Beutler Heating & Air Conditioning
Andreson	Larry	Speciality AC Products
Segerstrom	Charles	PG&E
Griffith	Ed	Morrison Homes
Sherman	Russ	Meyers Homes

San Francisco - Nonresidential Commissioning Group, June 5, 6:00 PM		
Last Name	**First Name**	**Affiliation**
Gillespie	Kenneth	PG&E
Hydeman	Mark	Taylor Engineering
Gruszynski	Dennis	Yamas Co.
Piette	Mary Ann	Lawrence Berkeley Lab
Blaevoet	Jeff	Guttman & Blaevoet
Macgregor	Alisdair	Ove Arup
Lehrer	David	Gensler
Mantoani	Glen	Barrington Controls
Ahmed	Shakeel	Ajmani & Pamidi

San Francisco - Insurance Litigation Group, June 5, 8:00 PM			CANCELLED
Last Name	**First Name**	**Affiliation**	
Caurant	Michel	Dealey, Renton & Associates	
Griffiths	John		
Romano	Tony	CNA Insurance	
Vine	Ed	LBL	
Schwartz	Jeremy	West Coast Property	

SOUTHERN CALIFORNIA

Irvine - Residential Diagnostic Testing Group, June 6, 6:00 PM		
Last Name	**First Name**	**Affiliation**
Harrold	Mark	City of Temecula
Johnson	Jim	City of Indian Wells
Blane	Brian	California Pacific Homes
Olson	Erik	MJB (engineer)
Johnson	Scott	energy efficiency consultant
Borders	Russel	Lucas & Mercier Co.
Loftus	Jeff	Aliso Air (HVAC)

Irvine - Nonresidential Commissioning Group, June 6, 8:00 PM		
Last Name	**First Name**	**Affiliation**
Iyengar	Kuppaswamy ("	KI Associates
Pierce	Tony	Southern California Edison
Lunneberg	Tom	CTG
Schiess	Klaus	KS Engineers
Duncan	Scott	Retrofit Originality
Kjellmon	Christie	formerly with Envest (SCE)
Lebon	Greg	Taisci
Hofferber	Craig	CFH Systems

San Diego - Insurance Litigation Group, June 7, 6:00 PM		
Last Name	**First Name**	**Affiliation**
Howard	Rich	Pacific Property Consultants
Parra	Dennis	D. E. Parra & Associates
Scattergood	Ian	
Comstock	James	Comstock Building Evaluation
Bentz	Paul	West Coast Property
Muckler	Neal	Asset Inspection & Consulting Services
Luhr	Stan	
Prinslow	Mike	Brookfield Homes

B. INTERVIEW GUIDE

Recruiting

Hi, my name is ____________________, and I'm calling from Pacific Consulting Services. May I please speak to ___________**[read contact name]** _____________?

[IF FURTHER EXPLANATION REQUIRED – READ] I am working with California utilities and the California Energy Commission on an assessment of strategies for improving the energy efficiency and overall construction quality of new buildings in California. We are also exploring avenues for closer coordination between Title 24 support activities and publicly funded energy efficiency programs. As part of this study, we are talking to experts such as _______**[contact]**__, about these issues. **[contact]**______ should have received a letter from PG&E and the CEC informing (HIM/HER) that I would be calling.

[WHEN CONTACT ON PHONE – READ] Hello, my name is ___________ _______ and I am with Pacific Consulting Services. I am working with California utilities and the California Energy Commission on a study that is looking at the industry's effectiveness in installing energy efficiency measures. You might recall receiving a letter about our study. [**IF RESPONDENT DOESN'T RECALL LETTER]** Basically, the study is examining public goods charge (PGC) programs in relation to Title 24 building energy efficiency standards – and has two objectives:

- To assess strategies for improving the energy efficiency and overall construction quality of new buildings in California through the Title 24 standards, and
- To explore avenues for closer coordination between Title 24 and PGC programs.

[ALL] You have been identified as being particularly knowledgeable in your field, and I am confident that the study results would be greatly enhanced if I can interview you. I am calling you today to see if I can make an appointment with you to discuss some of the issues we're investigating. The interview will cover such topics as testing and inspections, energy efficiency financing, insurance issues, callbacks and quality construction, building commissioning and energy codes, and energy standards development and implementation.

- ❒ Yes → **CONTINUE WITH RECRUIT**
- ❒ No, not interested → **THANK AND TERMINATE**

In order to maximize our time together, I'd like to first (determine/confirm) the topic areas that you are most familiar with and so that we can focus our discussion on the areas of your particular interest and input to the project.

R1. **[FILL IN TABLE TO DETERMINE MODULES TO USE]** How familiar are you with ___**(read each module title from first column A-I)**, then prompt with first row, Would you say…

	This is your Area of expertise	You are very knowledgeabe in this area	You are somewhat knowledgeable with aspects in this area, although it is not your area of expertise	You are not all that knowledgeable about this area
MODULE PRIORITY	**FIRST**	**SECOND**	**THIRD**	**SKIP**
A. Construction practices in building quality and call backs **(save this module for LAST)**				
B. Diagnostic testing and performance testing for residential buildings				
C. Building commissioning and performance testing for nonresidential buildings				
D. Energy efficiency financing (energy-efficient mortgages, performance contracting, building appraisals, etc.)				
E. Insurance/liability issues related to construction quality				
F. Energy-efficient building and green building initiatives				
G. Title 24 revision process				
H. Using Title 24 to promote energy efficiency program objectives				
I. Utility involvement in the Title 24 process				

Now that we (determined/ confirmed) your areas of expertise and interest, it looks like this interview will last about____**[add 30 minutes per module]**. With that in mind, is there a particular day and/or time that works best for you? Your input is crucial to the success of this project, and I am happy to schedule more than one interview time with you, if that is what works best for you.

Day(s): ______________________________Time(s): ______________________

I will call you on _______ at ___________, and I look forward to discussing these issues with you. Thank you very much.

Codes and Standards Data Collection Instrument

FOR ALL:

If calling back for appointment, read: Hello, my name is ____________ and I'm calling for __**[READ CONTACT NAME]**_____. **[Wait for respondent – continue]**. Hello Mr./Ms. ______**[contact]**______, this is _____________ and we had an appointment scheduled for today to discuss issues related to California energy standards. Is now still a good time for you?

- ❒ Yes – **[CONTINUE WITH MODULES]**
- ❒ No – **[Make alternate appointment date/time, thank and terminate]**

Module A: Construction Practices in Building Quality and Callbacks

This section focuses on construction practices in building quality and callbacks. We have read that there are several specific measures that tend to be more troublesome in terms of quality installation. In order to determine where your input will be best served, I'd like to just get a feel for your specific area of expertise.

A1. Are you most familiar with the residential market, the nonresidential market, or equally knowledgeable of both markets?

- ❒ Residential **[ASK ABOUT RESIDENTIAL MEASURES ONLY]**
- ❒ Nonresidential **[ASK ABOUT NONRESIDENTIAL MEASURES ONLY]**
- ❒ Both **[WHEN PROBING – MAKE SURE TO ASK ABOUT BOTH]**

A2. For the following building systems, which of the following are you most familiar with in terms of their specific construction practices and performance? **[READ OPTIONS AND CHECK APPROPRIATE BOXES]**.

With respect to	Expert/Extremely Familiar		Very Familiar		Somewhat Familiar		Not Very/Not at all Familiar	
	RES	NON	RES	NON	RES	NON	RES	NON
Lighting (nonres)								
HVAC								
Building Envelope								

ASK ONLY END USE QUESTIONS THAT RESPONDENT IS "EXPERT" OR "VERY FAMILIAR" WITH. KEEP THIS TABLE NEARBY TO REFER TO THROUGHOUT MEASURE AND END-USE QUESTIONS.

RESIDENTIAL

HVAC

Being familiar with residential HVAC construction practices, I'd like to discuss some of the performance issues related to this end use.

RESA3. What sorts of performance issues are you aware of with respect to residential HVAC equipment? **[check all mentioned] THEN: Probe on those NOT mentioned… "have you experienced any problems with ______[read measure]______?"**

Mentioned:	Prompted:
❒ Equipment efficiency efficiency	❒ Equipment
❒ Duct design and airflow airflow	❒ Duct design and
❒ Duct sealing	❒ Duct sealing
❒ Zone control	❒ Zone control
❒ HVAC installation (refrigerant charge, airflow)	❒ HVAC installation
❒ Other:______________________________	

For each measure mentioned, use "MEASURE SHEET"

Envelope

Being familiar with building envelope construction practices, I'd like to discuss some of the performance issues related to this end use.

RESA4. What sorts of performance issues are you aware of with respect to residential building envelope measures? **[check all mentioned] THEN: Probe on those NOT mentioned… "have you experienced any problems with _[read measure]_______?"**

Mentioned:	Prompted:
❒ Envelope sealing and air barrier	❒ Envelope sealing and air barrier
❒ Excess Framing	❒ Excess Framing
❒ Pressure differentials	❒ Pressure differentials
❒ Insulation	❒ Insulation
❒ Other: _________________	

For each measure mentioned, use "MEASURE SHEET"

Nonresidential

Lighting

The first area I'd like to ask you about is with nonresidential lighting.

NRESA6. What sorts of performance issues are you aware of with respect to lighting? **[check all mentioned] THEN: Probe on those NOT mentioned… "have you experienced any problems with ____[read measure]___________?"**

Mentioned:	Prompted:
❒ Occupancy Sensor Controls Controls	❒ Occupancy Sensor
❒ Daylighting Controls	❒ Daylighting Controls
❒ Other Lighting Controls (e.g., EMS systems, night and weekend shutoff, bi-level switching	❒ Other Lighting Controls
❒ Other: ________________________	

For each measure mentioned, use "**MEASURE SHEET"**

HVAC

Being familiar with nonresidential HVAC construction practices, I'd like to discuss some of the performance issues related to this end use.

NRESA6. What sorts of performance issues you have experienced with nonresidential HVAC equipment? **[check all mentioned] THEN: Probe on those NOT mentioned… "have you experienced any problems with ___[read measure]?"**

(PROBE WITH BULLETS FOR SPECIFICITY)	**Mentioned**	**Prompted**
Packaged air conditioners (typically rooftop)		
Equipment efficiency (compressor or fan)	❒	❒
Equipment sizing	❒	❒
Economizer	❒	❒
Equipment part load performance	❒	❒
Automatic scheduling and shutoff controls	❒	❒
Setback controls	❒	❒
Other:	❒	❒
Chilled water plant		
Equipment efficiency (chiller, cooling tower, pumps)	❒	❒
Equipment sizing (chiller, cooling tower, pumps and piping)	❒	❒
Chiller part load performance	❒	❒
Variable speed pump control	❒	❒
Interaction of components	❒	❒
Other:	❒	❒

Hot water plant		
Boiler efficiency	❒	❒
Equipment sizing (boiler, pumps and piping)	❒	❒
Boiler part load performance	❒	❒
Variable speed pump control	❒	❒
Other:	❒	❒
Air distribution system		
Fan sizing (air flow)	❒	❒
Cooling coil sizing	❒	❒
Variable speed fan control (supply air pressure control)	❒	❒
Supply air temperature control (reset supply air temperature based on outdoor temperature or on zone conditions)	❒	❒
Economizer	❒	❒
Zone temperature control (VAV box performance, reheat coil performance, temperature sensor problems, testing and balancing oversights)	❒	❒
	❒	❒
Ducts (duct sizing and layout, duct construction, and testing and balancing information)	❒	❒
Other:	❒	❒

Envelope

Since you said you were very familiar with nonresidential building envelope construction practices, I'd like to discuss some of the performance issues related to this end use.

NRESA7. What sorts of performance issues you have experienced with nonresidential building envelope measures? **[check all mentioned] THEN: Probe on those NOT mentioned… "have you experienced any problems with ___[read measure]?"**

Mentioned:	Prompted:
❐ Envelope defects that contribute to indoor air quality,moisture problems	❐ Envelope defects
❐ Other: __________________	

For each measure mentioned, use "MEASURE SHEET"

Measure Sheet (USE ONE SHEET PER MEASURE)

Expert Name: ____
End Use: ____
Residential/Nonresidential:_________________________________
Measure: ____

1. What sorts of performance issues have you experienced with this specific measure? _______________________________________
____
____
____
____
____
____
____
____

2. What do you think are the causes of these problems? For example, do you think they are related to problems with the initial specifications, the installation, operation or maintenance? **(PROBE: design, manufacturer, product quality)** __________________
____
____
____
____
____
____
____
____

3. About how many **CALLBACKS (RES) / CHANGE ORDERS (NONRES)** result from these types of problems, on average? _

4. What is the typical cost of a callback with problems such as these? _________

5. Who is actually paying for these callbacks? **(PROMPT)**

   ❒ Distributor
   ❒ Buyer
   ❒ Subcontractor
   ❒ General contractor
   ❒ Manufacturer
   ❒ Other: __________________________

6. Is it common to factor in additional costs in the initial bid to cover the potential callback? And, if so, how much is typical? ______
____
____
____
____

7. Do you have any information on the frequency of performance problems such as these throughout the state of California? ____
____

8. Do you have any solutions you could recommend that would address these/this issue?______________________________________
____
____
____
____
____
____
____
____

GO TO NEXT MODULE

Module B: Building Testing and Performance for Residential Buildings

In this section, we will discuss various aspects related to residential building testing and performance.

B1. What do you think is the value is of testing a residential building's performance? Do you think it is worthwhile? ____________________

B2. Why aren't more homes being tested? We've read that these diagnostics tests are not being widely accepted in the market, why do you think this is? ____________________

B3. What do you think the "trends" are in terms of testing? **(PROBE: Do you think it is a growing industry? Are people asking for this?)**

B4. What do you consider to be "road blocks" to residential building diagnostics and testing? **[PROBE WITH BARRIERS]**

- ❒ additional costs
- ❒ lack of awareness of the energy benefits and long term economic savings benefits
- ❒ lack of financial incentives
- ❒ lack of awareness of who are the service providers
- ❒ lack of a standardized methodology and testing procedures that would make the process of diagnostics more efficient, cost effective and accessible and making this information available
- ❒ lack of understanding of impact on indoor air quality, moisture control, health and safety
- ❒ lack of awareness of potential to avoid liability, callbacks, litigation
- ❒ other:____

FOR EACH BARRIER, ASK:

B5. How is _**[insert first barrier]**____a road block to residential diagnostics and testing? ____

____

____

____

____

____

____

____

____

B5a. How is _**[insert next barrier]**____ a road block to residential diagnostics and testing? ____

____

____

____

____

____

____

B5b. How is **[insert next barrier]** a road block to residential diagnostics and testing? ____________________

B5c. How is **[insert next barrier]** a road block to residential diagnostics and testing? ____________________

B6. What kinds of policy options can you recommend for expanding the use of residential building diagnostics? ____________________

B7. Is there an opportunity to expand residential diagnostics by linking them with other energy efficiency programs? If so, how? ____________________

B8. Is there an opportunity to expand diagnostics by linking them with building standards? If so, how? ______________________________

____

____

____

B9. Is there an opportunity to expand residential building diagnostics by linking them with insurance or liability options? ________________

____

____

____

____

____

____

____

____

____

____

GO TO NEXT MODULE

Module C: Building Commissioning and Performance Testing for Nonresidential Buildings

In this section, we will discuss various aspects related to building commissioning in the nonresidential new construction and retrofit markets.

C1. What do you think is the value of building commissioning? Do you think it is worthwhile? ____

C2. Why aren't more buildings being commissioned? We've read that there is trouble having commissioning being widely accepted in the market, why do you think this is? ____________________________________

C3. What do you think the "trends" are in terms of commissioning? **(PROBE: Do you think it is a growing industry? Are people asking for this?)**____

C4. What do you consider to be "road blocks" to commercial building commissioning and performance testing? **[PROBE WITH BARRIERS]**

- ❒ additional project costs
- ❒ lack of awareness of the energy benefits and long term economic savings benefits
- ❒ lack of financial incentives
- ❒ lack of a clear understanding of what building commissioning implies
- ❒ who are the service providers
- ❒ lack of infrastructure
- ❒ lack of quality assurance
- ❒ lack of a standardized methodology and testing procedures that would make the process of commissioning more efficient cost effective and accessible and making this information available
- ❒ lack of efficient marketing coordination and communication amongst the commissioning team
- ❒ lack of awareness on part of building owners and managers that a proposed Energy Conservation Measure (ECM) may not work without commissioning
- ❒ extra time and paperwork associated with the commissioning process
- ❒ lack of requirements for building commissioning in the Standards
- ❒ lack of understanding of impact on indoor air quality, moisture control, health and safety, and productivity.
- ❒ lack of awareness of potential to avoid liability, callbacks, litigation and tenant complaints
- ❒ other: ____

FOR EACH BARRIER, ASK:

C5. How is _**[insert first barrier]**____ a road block to commercial building commissioning and performance testing? ____________________

____

____

____

____

____

____

C5a. How is _**[insert next barrier]**____ a road block to commercial building commissioning and performance testing? ____________________

____

____

____

____

____

C5b. How is _**[insert next barrier]**____ a road block to commercial building commissioning and performance testing? ____________________

____

____

____

____

____

C5c. How is _**[insert next barrier]**____ a road block to commercial building commissioning and performance testing? ____________________

____

____

____

____

____

____

C6. What kinds of policy options can you recommend for expanding the use of building commissioning? ________________________________

____

____

____

____

____

____

____

C7. Is there an opportunity to expand building commissioning by linking it with other energy efficiency programs? If so, how? _____________

____

____

____

____

____

____

C8. Is there an opportunity to expand building commissioning by linking it with building standards? If so, how? _________________________

____

____

____

____

____

C9. Is there an opportunity to expand building commissioning by linking it with insurance or liability options? ___________________________

____

____

____

____

____

____

GO TO NEXT MODULE

Module D: Financing

In this section, we will discuss some of the financing options available in the marketplace that specifically fund energy efficiency improvements.

Currently, there are several ways of financing residential energy efficiency improvements: either through Federal programs and lending institutions, such as Fannie Mae, or through private or secondary lending institutions who offer Energy Efficient Mortgages (EEMs) as part of their portfolio of options. On the nonresidential side, through mechanisms such as performance contracting.

(READ) Let's talk first about the residential sector.

D1. What has your personal experience been with Energy Efficient Mortgages in the residential sector **(IF NO RESIDENTIAL EXPERIENCE, SKIP TO NONRESIDENTIAL QUESTIONS)**? ___

____

____

____

____

____

____

____

____

____

D2. In your opinion, in what ways do lenders stand to benefit by offering energy efficient mortgages?______________________

____

____

____

____

____

____

____

D3. What are some of the reasons why lenders **would not** want to offer these types of mortgages? (**PROBE and CIRCLE ALL THAT APPLY)**

1. Increased risk
2. Uncertainty about true energy savings
3. Lack of awareness on their part of the benefits of EEMs
4. EEMs do not yield enough profit
5. Difficulty selling on secondary market
6. Appraisers don't consider energy efficiency improvements in assessing home value
7. Other ____

D3a. Which barrier would you consider to be most important?____

D3b. Which barrier would you consider to be next most important?

____

D3c. Which barrier would you consider to be third most important?

____

D4a. Do you think diagnostic testing would alleviate **(READ FIRST "MOST IMPORTANT" BARRIER)?** If so, how so? If not, why not? ______

____

____

____

____

____

____

____

D4b. Do you think diagnostic testing would alleviate **(READ SECOND BARRIER)?** If so, how so? If not, why not? __________________

____

____

____

____

____

____

D4c. Do you think diagnostic testing would alleviate **(READ THIRD BARRIER)?** If so, how so? If not, why not? ____________________

D5. What kinds of "policy options" would you recommend for expanding the use of energy efficient mortgages? (**PROBE IF NECESSARY)** For example, HUD and other Federal lending institutions such as Fannie Mae, require a HERS rating as a prerequisite for all energy efficient loan they process. Can you think of any other policies such as this one that might encourage consumers to use EEMs?____________________

D6. Is there an opportunity to expand their use by linking them with other energy efficiency programs? If so, how? ____________________

D7. Is there an opportunity to expand their use by linking them with diagnostic testing? If so, how? ____________________

(READ): Let's talk next about the nonresidential sector.

D8. What has your personal experience been with financing energy efficiency measures in nonresidential facilities, either as retrofit projects or as part of new construction projects? ____________________
____
____
____
____
____
____
____

D9. In your opinion, in what ways do lenders stand to benefit by financing energy efficiency?____
____
____
____
____
____
____
____
____
____

D10. What are some of the reasons why financing energy efficiency may be difficult in the Nonresidential sector? (**PROBE and CHECK ALL THAT APPLY)**

1. Lenders perceive increased risk
2. Building owners, ESCOs, or lenders uncertain about true energy savings
3. Lack of awareness of the benefits of energy efficiency
4. Building owners concerned about non-energy consequences (effect on indoor air quality, worker productivity, customer comfort, visual aesthetics, etc.)
5. Business focus on increasing revenues rather than reducing costs
6. Lenders have difficulty selling loans on secondary market

7. Appraisers don't consider energy efficiency in assessing building value
8. Other ____

D10a. Which barrier would you consider to be most important?___
____

D10b. Which barrier would you consider to be next most important?
____

D10c. Which barrier would you consider to be third most important?
____

D11. Do you think building commissioning would alleviate **(READ FIRST BARRIER)?** If so, how so? If not, why not? ___________________
____
____
____
____
____
____
____
____

D11a. Do you think building commissioning would alleviate **(READ SECOND BARRIER)?** If so, how so? If not, why not? ___________________
____
____
____
____
____
____
____

D11b. Do you think building commissioning would alleviate **(READ THIRD BARRIER)?** If so, how so? If not, why not? ____________________

____

____

____

____

____

____

____

D12. What kinds of "policy options" would you recommend for expanding the availability of financing for energy efficiency projects?___________

____

____

____

____

____

____

____

____

D13. Is there an opportunity to expand financing availability via publicly funded energy efficiency programs? If so, how? (**PROBE FOR MECHANISMS THAT DON'T INVOLVE DIRECT SUBSIDIES FOR PROJECTS**) ____
____
____
____
____
____

D14. Is there an opportunity to expand financing availability by promoting building commissioning? If so, how? ________________________
____
____
____
____
____
____

GO TO NEXT MODULE

Module E: Insurance/Liability Issues Related to Construction Quality

In this section, I'd like to explore some of the insurance and liability issues in the energy efficiency market place, if any, and then gain your opinions about them.

E1. What do you think are the insurance benefits to be gained through better construction practices? ______________________________

E2. With respect to building performance, what is the source of problem? Are insurance and liability issues related mostly to lighting systems? HVAC systems? Building envelope? ________________________

E3. Why do you think most of the problems occur? For example, do you think it is more related to manufacturing of the equipment? ______

E4. Would insurance premiums be reduced for builders? If yes, by how much, and which ***type*** of insurance premiums (e.g., liability, safety)?

E4a. Would litigation costs be reduced for builders?

E5. What kinds of policies or initiatives would you recommend to promote higher quality construction as a means of reducing insurance premiums and losses and managing risk?

E6. Would linking insurance premiums with energy efficiency programs improve construction practices? If so, how?

E7. Is there an opportunity to improve construction practices by linking insurance with building commissioning or diagnostic testing? If so, how? ____
____
____
____
____
____
____
____

GO TO NEXT MODULE

Module F: Linkages to Other Initiatives

F1. What is your role or relationship with __________ **[fill in program or initiative]**?____

____
____
____
____
____
____

F2. Which private sector market actors does the initiative target? **[check all that apply and ask corresponding LETTERED probing questions]**

Residential	Nonresidential
9. Builders and developers **(i)**	❐ Building owners **(vi)**
10. Architects, Title 24 consultants, designers **(ii)**	❐ Architects, Title 24 consultants, designers (mech., structural, & elec. engrs.) **(vii)**
11. Contractors **(iii)**	❐ General contractors **(viii)**
12. Realtors and lenders **(iv)**	❐ Subcontractors **(ix)**
13. Home owners and buyers **(v)**	❐ Bldg. occupants, tenants **(x)**
14. Other: _______________	❐ Other: __________

Residential

i. What benefits does the initiative offer **residential builders and developers** who increase the energy efficiency or the construction quality of their homes?__________________________________

PROBE AS NECESSARY ON THE FOLLOWING LIST:
Minimize construction costs
Maximize home sale values
Differentiate product from competition
Minimizing construction project time
Minimize performance problems and callbacks
Avoid liability or litigation

What strategies does the initiative use to promote those benefits?

ii. What benefits does the initiative offer **architects and designers** who specify energy efficiency or construction quality elements in their designs?____

What strategies does the initiative use to promote those benefits?

iii. What benefits does the initiative offer **residential contractors** who incorporate energy efficiency or quality construction practices into their business?

PROBE AS NECESSARY ON THE FOLLOWING LIST:
Reduce project costs
Streamline the construction process
Improve their work product
Reduce callbacks
Avoid liability or litigation

What strategies does the initiative use to promote those benefits?

iv. What benefits does the initiative offer **Realtors and lenders** who promote or finance energy efficient homes?

PROBE AS NECESSARY ON THE FOLLOWING LIST:
Enhance sales commissions
Minimize the time it takes to sell a home
Protect their business reputations
Avoid risk, litigation, and liability related to construction defects
Ability to close sale

What strategies does the initiative use to promote those benefits?_
____
____
____
____
____
____

v. What benefits does the initiative offer **home buyers** who purchase energy efficient homes?_________________________________
____
____
____
____
____

PROBE AS NECESSARY ON THE FOLLOWING LIST:
Lower energy bills
Increase comfort
Maintain greater control of the indoor environment

What strategies does the initiative use to promote those benefits?_
____
____
____
____
____
____
____
____

Nonresidential

vi. What benefits does the initiative offer **nonresidential building owners** who improve performance of building systems or building construction quality, relating to energy (e.g., envelope, HVAC, lighting)?______

____

____

____

____

____

PROBE AS NECESSARY ON THE FOLLOWING LIST:
Minimize construction costs
Maximize building values
Differentiate product from competition
Minimizing construction project time
Minimize performance problems and callbacks

What strategies does the initiative use to promote those benefits? (**PROBE FOR COMMISSIONING, DIAGNOSTIC TESTING**)_____

____

____

____

____

____

____

____

____

vii. What benefits does the initiative offer **nonresidential architects and designers** who specify energy efficiency or construction quality elements in their designs?_________________________________

____

____

____

____

____

____

____

What strategies does the initiative use to promote those benefits?_

____

____

____

____

____

____

____

viii. What benefits does the initiative offer **general contractors** who increase the energy efficiency or the construction quality of their buildings?____

____

____

____

____

____

____

____

What strategies does the initiative use to promote those benefits?_

____

____

____

____

ix. What benefits does the initiative offer **subcontractors** who increase the energy efficiency or the construction quality of their buildings?____

____

____

____

____

____

____

____

What strategies does the initiative use to promote those benefits?_
____

x. What benefits does the initiative offer **building occupants and tenants** who insist on energy efficiency or construction quality of their buildings?_
____

What strategies does the initiative use to promote those benefits?_
____

ASK ALL:

F3. In what ways would you say the initiative relates, directly or indirectly, to energy codes and standards?________________________________

F4. To the extent that the initiative was designed specifically to influence energy codes and standards, in what ways has it been successful?

F5. In what ways has it fallen short of expectations?_______________

F6. What lessons would you draw from those efforts for more effectively influencing codes and standards in the future?________________

GO TO NEXT MODULE

Module G: Title 24 Revision Process

The CEC administers changes to Title 24 in three-year cycles. The most recent revision took place in 1998.

G1. What are the basic steps in the revision process?______________

G2. Where do these steps take place?___________________________

G3. What is the time frame for each step?________________________

G4. What guiding principles determine whether a recommended change is within the scope of Title 24 or not?__________________________

G5. What function do CEC staff serve?

G6. What function do CEC commissioners serve?

G7. Who are the key stakeholders?

G7a. What *interests* drive key stakeholders?

G8. How do individuals and organizations go about establishing themselves as stakeholders?

G9. How do stakeholders go about making their needs and interests known?

G10. How do stakeholders exert pressure and influence?

G11. How does CEC staff balance or weigh competing interests? How are disputes settled?

G12. How is information about the process and potential results communicated to stakeholders and the world at large?

G13. What was your personal role in the most recent round of revisions?

G14. From your experience, what steps or activities are necessary for a stakeholder to be effective in influencing the direction of revisions?

G15. What would be your top priority for future changes in the standards? How might the standards be improved?

G16. Do you think the standards would benefit from simplification in some way? What simplifying changes would you recommend?________

____

____

____

____

____

____

____

____

____

G17. Do you think standards should be tightened over time as the technologies improve? Why or why not?_____________________

____

____

____

____

____

____

____

____

G17a. Why do some stakeholders resist tightening standards?_________

____

____

____

____

G17b. How can consensus be built to require tighter standards? ________

____

____

____

____

____

GO TO NEXT MODULE

Module H: Using Title 24 to Promote Program Objectives

I'd like to first ask you some questions about the role of standards in promoting energy efficiency.

H1. In your assessment, what is the appropriate role of standards in the broader energy efficiency context? What is the public policy rationale for a government role, via standards, in the energy efficiency of construction projects?

H2. In what ways do California energy standards address the public interest in energy efficiency?

H3. In what ways do the standards fall short of meeting that public interest?

H4. How important is it that the standards incorporate, either through requirements or performance standards compliance options, emerging energy-efficient technologies and practices?__________________

____

____

____

____

____

____

____

____

(READ) Next, I'd like to ask you some questions about the role of publicly funded energy efficiency or market transformation programs in promoting energy efficiency.

H5. In your assessment, what is the appropriate role of energy efficiency or market transformation programs in the broader energy efficiency context? What is the public policy rationale for a government role, via these programs, in the energy efficiency of construction projects?_

____

____

____

____

____

____

____

____

H6. In what ways do California programs address the public interest in energy efficiency?____

____

____

____

____

____

____

H7. In what ways do they fall short of meeting that public interest?

H8. What opportunities do you see for better integrating the standards and the programs to more effectively promote common objectives?

H9. To the extent that California's energy standards and publicly funded energy efficiency programs share goals and objectives (e.g., energy efficiency), how effectively are they coordinated to achieve those common objectives?

H10. Can you point to particular examples where the standards and the programs work at cross-purposes?

GO TO NEXT MODULE

Module I: Utility Involvement in Title 24 Process

I'd like to ask you some questions about how energy programs influence standards requirements or implementation. For the sake of specificity, I'd like you to think of a single program about which you are particularly knowledgeable.

I1. How would you describe that program in terms of:

End uses____

Technologies____

Private sector market actors targeted (e.g., consumers, manufacturers, contractors, etc.)_______________________________________

____

Influence mechanism (e.g., rebates, ad campaigns, training programs, R&D)____

____

Primary effects on the market______________________________

____

____

____

____

I2. What was your role or relationship with the program?__________

____

____

I3. In what ways would you say the program contributed to revising the energy standards or implementing them?____________________

____

____

____

____

____

____

I4. Did the program uncover any problematic building practice or technology that was ultimately addressed in the energy standards?_

____
____
____
____
____
____
____
____

I5. Did the program improve compliance (e.g., offer training for contractors or inspectors, offer testing or inspections, link program incentives to compliance, highlight compliance through labeling, etc.)? Did the program document or verify compliance? ____________________

____
____
____
____
____
____
____
____
____
____

I6. Did the program document the extent and nature of known problematic building practices or technologies?_________________________

____
____
____
____
____
____
____

I7. Did program staff engage in any public-interest advocacy to address known problem? In particular, did staff participate in any way in the standards revision process?________________________________

I8. Did the program fund R&D activities that led to or is expected to lead to changes in the energy standards (e.g., develop computer codes, compliance techniques, support NFRC, CEE)?________________

I9. Did the program stimulate production, marketing, or distribution of a new technology innovation that was or might be incorporated into the energy standards?____

I10. Did the program stimulate knowledge, awareness, and adoption of new technologies or building practices that were or might be incorporated into the energy standards?______________________________

I11. To the extent that the program manager(s) set out consciously to influence the standards development and implementation process (rather than as a side effect), in what ways were their efforts successful?______________________________

I12. In what ways did their efforts fall short of expectations?_________

I13. What lessons would you draw from those efforts for more effectively influencing the standards in the future?______________________

I14. Did the program uncover or remedy problems with energy efficiency standards or their implementation? ______________________________

____

____

____

____

____

____

ASK: Can you recall another program that you've also been involved with, that may have resulted in similar findings, or even different findings?

15. YES – complete second Module I with next program.
16. NO – go to next module, or thank and terminate interview.

C. FOCUS GROUP DISCUSSION GUIDES

Residential Diagnostic Testing Focus Group Guide

I. Introduction

a) Who we are

b) Sponsor of the study. This study is being sponsored by PG&E, and is supported by SCE, SDG&E, SCG, and the California Energy Commission; it is a statewide study.

c) Background of study – Basically, the study is examining public goods charge (PGC) programs in relation to Title 24 building energy efficiency standards. One of the objectives that we'll be discussing today is to assess strategies for improving the energy efficiency and overall construction quality of new buildings in California through the Title 24 standards.

   Over the past few months we've been collecting information from industry experts to support our assessment. However, there are still a few areas that need further exploration.

d) Some of you may have already been interviewed, but we still have some outstanding questions and issues that we will cover here today.

e) What findings will be used for – The results of our focus groups will assist in our recommendations to utility program planners, the CEC, and other policy making entities about planning for improving energy efficiency.

f) Participant introductions – Let's quickly go around the room and just tell everyone your name and your affiliation.

g) Ground rules: confidentiality, courtesy for all view points

II. Discussion: Review Key Building Performance Issues

Based on a literature review and in depth interviews with industry experts, we have concluded that there are two main building performance issues that exist FROM AN ENERGY EFFICIENCY PERSPECTIVE. We recognize that these issues may not be the issues that get the most call backs, and they may not be the issues that end up going to court for defects; however, they are the areas that seem to have the highest energy efficiency implications. **(SHOW GRAPHIC WITH DEFECTS LISTED)**

a) HVAC installation and design problems

- Incorrect refrigerant charge – identified as being a problem in over 70% of installations nationally.
- Inadequate system airflow over the indoor coil – usually due to reliance on rule-of-thumb duct sizing procedures.
- Duct leakage
- System oversizing, which has been projected to be as high as 47% over Manual J prescribed sizing.

b) Building Envelope: Defects in the installation of insulation are common, including voids, gaps, and compressions. Defects also are common in air and moisture sealing of the envelope.

III. Our Solution – Systems Approach to Home Construction

We have concluded that significant gains in energy efficiency can be achieved by improving overall building construction quality and mitigating construction defects through a systems approach to home construction. By "systems approach" we mean a construction process that includes

- A mechanical design of the HVAC and ducts as part of the initial blueprints, considering house orientation, windows, lighting, and insulation on HVAC loads
- Performance testing of the ducts and HVAC system
- One or more envelope inspections to verify quality of the insulation installation and air and moisture sealing.

- Verification and documentation that all building systems perform interactively in accordance with the design documentation and intent, and in accordance with the owner's operational needs

As such we have compiled a list of recommendations that speak to this systems approach. First what I'd like to do is just show you what we've come up with for recommendations. Then, once we look at these, we'll talk about each of them in depth. So, let's just go through them.

RECOMMENDATIONS AND RATIONALES (TO BE SHOWN GRAPHICALLY):

1. ***Recommendation***: Require "house as a system" approach for all homes built in California. Require mechanical drawings as part of design documents required for building permit. Require satisfactory inspection results and performance testing reports as precondition for issuing occupancy permit.

   Rationale: Requirement applies uniformly to all projects, maximizes energy efficiency gains if properly enforced.

   Alternative A: Require all builders to hire third party inspectors, at their own expense, to inspect, test, and certify envelope and HVAC systems for **all** homes they build.

   Rationale: This approach provides the most rigorous quality control.

   Alternative B: Require all builders to hire third party inspectors, at their own expense, to inspect, test, and certify envelope and HVAC systems for a sample of the homes they build.

   Rationale: This approach most closely resembles current Title 24 mechanism.

   Alternative C: Require certification of HVAC and insulation contractors. Tie the certification to successful completion of training courses. Allow contractors to inspect and test their own installations. Require affidavit from contractors documenting satisfactory inspection results and performance testing reports as precondition for issuing occupancy permit.

Establish random third-party inspection mechanism for quality control, with multiple deficiencies being grounds for revoking business license.

Rationales: This will minimize the costs associated with third party testing and inspections. It will also improve knowledge, skill and ability on the part of contractors. Finally, it will address the concern for project delays due to a lack of performance testing infrastructure. However, it requires significant changes in the enforcement authority of the CEC, the state licensing board, or some other agency.

Alternative D: Allow contractors to inspect and test their own installations. Require affidavit from contractors documenting satisfactory inspection results and performance testing reports as precondition for issuing occupancy permit.

Rationales: By relying on the honor system, this eliminates the costs associated with third party testing and inspections and minimizes the concern for project delays. However, it does not assure adequate knowledge, skill and ability on the part of contractors. This approach provides the least rigorous quality control.

2. ***Recommendation***: Use public goods charge funds to offset costs of contractor training regarding diagnostic testing and revisions to Title 24.
   Rationale: This will improve overall knowledge, skill and ability on the part of contractors

3. ***Recommendation***: Conduct additional research to quantify potential non-energy benefits of a systems approach to home construction. Quantify the benefits from reduced callbacks and reduced exposure to litigation.
   Rationale: Addresses potential benefits to builders and subcontractors to avoid liability, callbacks and litigation. Additional research may convince insurers to lower insurance premiums for builders and contractors who are diligent in adopting "house as a system" construction practices.

4. ***Recommendation***: Step up consumer education efforts around construction quality issues, particularly in association with ENERGY STAR.
   Rationales: Addresses lack of consumer awareness of the extent of construction defects; addresses potential unwillingness of home buyers to pay for a systems approach to home construction.

5. ***Recommendation***: Simplify Title 24. Include substantive input from builders and contractors starting in the initial states of revision of the standards.
   Rationale: This will encourage wider acceptance of the procedures and reduce the costs associated with the systems approach to home construction.

6. ***Recommendation***: Offer a state tax credit for Green Buildings.
   Rationale: Addresses added cost issues for building and diagnostic testing.

IV. Test Recommendation Components

What I'd like to do now is look at each of these recommendations, and ask you all what you think the benefits and the drawbacks are for each market actor involved. I want to see who are the "winners and losers" for each recommendation.

1) So, let's start with the first recommendation **(READ 1)**. What are the benefits? What are the drawbacks?

2) Is this a viable solution for the marketplace – is it realistic?

3) How would you add to or tweak this recommendation?

Okay, now, looking at all the recommendations together, how does the entire "recommendation package" effect each market actor?

How can the entire "recommendation package" be modified to be more effective and less onerous?

What other recommendations do you have that would help the marketplace embrace residential diagnostic testing?

V. Close

That's about all the time we have this evening. I want to thank you all for coming and brainstorming with me tonight – your input is very valuable. You can collect your incentives at the front desk.

Nonresidential Commissioning Focus Group Guide

I. Introduction **(10 minutes)**

a) Who we are

b) Sponsor of the study. This study is being sponsored by PG&E, and is supported by SCE, SDG&E, SCG, and the California Energy Commission; it is a statewide study.

c) Background of study – This study is an assessment of strategies for improving the energy efficiency and overall construction quality of new buildings in California. Basically, the study is examining public goods charge (PGC) programs in relation to Title 24 building energy efficiency standards. One of the objectives that we'll be discussing today is to assess strategies for improving the energy efficiency and overall construction quality of new buildings in California through the Title 24 standards.

d) Over the past few months we've been collecting information from industry experts to support our assessment. However, there are still a few areas that need further exploration.

e) Some may have already been interviewed, but we still have some outstanding questions and issues that we will cover here today.

f) What findings will be used for – to make recommendations to utility program planners, the CEC, and other policy making entities about planning for improving energy efficiency.

g) Participant introductions – Let's quickly go around the room and just tell everyone your name and your affiliation.

h) Ground rules: confidentiality, courtesy for all view points

II. Discussion: Review Key Building Performance Issues

Based on a literature review, and in-depth interviews with industry experts, we have concluded that there are two main building performance issues that exist FROM AN ENERGY EFFICIENCY PERSPECTIVE and they are HVAC and Lighting controls systems. These seem to be the biggest issues because they are the most complex. So here are the systems and components that have come up the most often in our discussions and readings that can be improved. **(SHOW GRAPHIC THAT WILL HAVE DEFECTS LISTED)**

a) HVAC installation and design problems

- Equipment sizing and duct sizing: oversized to compensate for other deficiencies
- Chilled water plants – Performance issues with temperature controls on the condenser water, variable speed pump controls, and component interactions. Systems do not operate efficiently under part-load conditions due to "Delta T Syndrome" when chilled water flow doesn't drop in response to reduction in load.
- Air distribution systems – Biggest source of nonresidential HVAC issues. Performance issues with variable speed fan controls. Zone temperature controls is an issue because no one installs dual temperature setpoints, which are required. Cooling coils undersized. Sensors on economizers get set improperly.
- Packaged air conditioners – they don’t perform efficiently under part-load conditions. Dampers stick on economizers due to manufacturer defect. Cycling on and off is not an efficient operating mode and energy standards do not require economizers for these systems. Automatic scheduling and shutoff controls were also mentioned as having performance issues.

b) Lighting Control Systems

- Occupancy sensor controls – lights shut off when space is occupied. Control systems set improperly or are over-ridden by facility managers who do not understand how to program them.
- Daylighting controls and other lighting controls

III. Our Solution – Make Building Commissioning Standard Practice

We have concluded that significant gains in energy efficiency can be achieved by improving overall building construction quality and mitigating construction defects through building commissioning. As there are many different definitions of what commissioning implies, for our purposes, we will use this definition. (**SHOW GRAPHIC THAT HAS FOLLOWING DEFINITION**: "Commissioning is a systematic process of assuring by verification and documentation, from the design phase to a minimum of one year after construction, that all building facility systems perform interactively in accordance with the design documentation and intent, and in accordance with the owners operational needs, including preparation of operation personnel." [from Bjornskov, et al. ACEEE 1996]).

We consider building commissioning to include the following seven elements **(SHOW NEXT GRAPHIC THAT LISTS THESE STEPS)**:

1. Commissioning plan at the predesign phase
2. Independent commissioning agent from outset
3. Customized test plan as part of project design documents
4. Review systems installation throughout and oversee functional testing
5. Operation and maintenance manuals and plans
6. Training plans
7. Final commissioning report for building owner

So, what's the problem? What are we looking to solve?

Throughout our study we've recognized that energy efficiency is determined by, among other things, three main areas:

1) design
2) choice of materials and technologies
3) and construction practices

Our main focus is on construction practices because in our view those are the hardest issues to regulate in Title 24 language. We are interested in design elements as well, but only to the extent they play a role in energy efficiency. We are focusing less attention on materials – not that they are not important, but other studies are looking into that.

With that in mind, we have compiled a list of recommendations that speak to this commissioning approach. First what I'd like to do is just show you what we've come up with for recommendations. Then, once we look at these, we'll talk about each of them in depth. So, let's just go through them. **(Show recommendations one at a time and read 'rationale' for each recommendation)**.

Please keep in mind that these recommendations are CONCEPTUAL. We don't necessarily think that all of these are realistic or viable. However, we're looking to you for your input on the recommendations that are worthy of further exploration.

For each recommendation, there is also a rationale behind why we recommended it. I'd also like to point out there are pre-conditions that need to be in place before actually implementing these recommendations. They also vary with respect to being a short term solution, to a long term solution, or goal.

RECOMMENDATIONS AND RATIONALES (TO BE SHOWN GRAPHICALLY):

1. ***Recommendation***: Require commissioning for all nonresidential buildings built in California. **LONG TERM**

   Rationale: Requirement applies uniformly to all projects. Maximizes energy efficiency gains, minimizes construction defects, and thoroughly documents construction process in the event parties involved are subject to a legal challenge

   Preconditions: That there is a common and accepted definition of commissioning. There is accepted testing/inspection protocols (whatever is cost-effective). Cost effectiveness has been thoroughly documented;

and there is a fully developed infrastructure (qualified agents, adequate training, any/all software that's needed is in place).

Alternative A: Include all seven commissioning elements.
Rationale: Maximizes energy efficiency gains if uniformly applied

Alternative B: Relax requirement for independent commissioning agent
Rationale: Minimizes commissioning costs

Alternative C: Require commissioning only of HVAC and lighting control systems
Rationale: Minimizes commissioning costs by focusing attention on systems with greatest performance issues. However, it may not provide necessary quality control to address insurance and litigation issues (fire, sprinklers, elevators, envelope).

Alternative D: Offer compliance credits for commissioning as an optional method for complying with Title 24.
Rationale: Makes commissioning voluntary rather than mandatory.

2. ***Recommendation***: Use public goods charge funds to offset costs of commissioning agent training and revisions to Title 24. **SHORT/MEDIUM TERM**
Rationale: This will improve overall knowledge, skill and ability on the part of contractors. It will also improve commissioning infrastructure and expertise, and provide a clear understanding of what building commissioning implies and who the service providers are.

3. ***Recommendation***: Develop simple and uniform testing protocols. **SHORT/MEDIUM TERM**
Rationale: This will reduce additional project costs, as well as provide standardized methodology and testing procedures that would make the process of commissioning more efficient, cost effective and accessible. It will also minimize extra time and paperwork associated with the commissioning process.

4. ***Recommendation***: Establish certification process for commissioning agents to make them more reputable and add standardization. **MEDIUM TERM SOLUTION**

   Rationales: This will create standardized methodology and testing procedures that would make the process of commissioning more efficient, cost effective, and accessible. It will also clear up any misunderstanding about what building commissioning implies and who the service providers are.

   Preconditions: That we've been able to come up with a certification process that adds credibility and standardization without becoming over onerous.

5. ***Recommendation:*** Conduct additional studies on costs and benefits for building commissioning, including a quantitative cost-benefit analysis of commissioning relative to energy and "non-energy" benefits, such as improved air-quality, better work environment resulting in higher productivity. **SHORT/MEDIUM TERM**

   Rationales: This will improve awareness of the energy benefits and long term economic savings benefits of commissioning. It will also improve skepticism on the part of building owners and managers that a proposed Energy Conservation Measure is going to work. Provide justification for reduced insurance rates.

6. ***Recommendation***: Offer a state tax credit for Green Buildings. **MEDIUM/LONG TERM**

   Rationale: Addresses added cost issues for commissioning. Addresses spectrum of owner/occupant concerns (health, safety, productivity, etc)

   Preconditions: That we have gained buy-in from a wide range of political interests.

IV. Test Recommendation Components

What I'd like to do now is look at each of these recommendations, and ask you all what you think the benefits and the drawbacks are.

So, let's start with the first recommendation **(READ 1)**. What are the benefits? What are the drawbacks?

Is this a viable solution for the marketplace – is it realistic?

How would you add to or tweak this recommendation?

Looking at all the recommendations together, how does the entire "recommendation package" affect each market actor?

How can the entire "recommendation package" be modified to be more effective and less onerous? If this were going to be one program, for example, how should it be modified to be the most effective?

V. Other recommendations

What other recommendations do you have that would help the marketplace embrace nonresidential building commissioning?

VI. Close

That's about all the time we have this evening. I want to thank you all for coming and brainstorming with me tonight – your input is very valuable. You can collect your incentives at the front desk.

Insurance Liability Focus Group Guide

I. Introduction

a) Who we are

b) Sponsor of the study. This study is being sponsored by PG&E, and is supported by SCE, SDG&E, SCG, and the California Energy Commission; it is a statewide study.

c) Background of study – This study is an assessment of strategies for improving the energy efficiency and overall construction quality of new buildings in California. Basically, the study is examining public goods charge (PGC) programs in relation to Title 24 building energy efficiency standards. One of the objectives that we'll be discussing today is to assess strategies for improving the energy efficiency and overall construction quality of new buildings in California through the Title 24 standards.

d) Over the past few months we've been collecting information from industry experts to support our assessment. However, there are still a few areas that need further exploration.

e) Some may have already been interviewed, but we still have some outstanding questions and issues that we will cover here today.

f) What findings will be used for – to make recommendations to utility program planners, the CEC, and other policy making entities about planning for improving energy efficiency.

g) Participant introductions – Let's quickly go around the room and just tell everyone your name and your affiliation.

h) Ground rules: confidentiality, courtesy for all view points

II. Review Links Between Construction Defects, Litigation Exposure, and Insurance Rates

1. What is the role of construction defect litigation in driving insurance rates? If it drives rates up, then by how much? What steps do insurance companies take to limit the costs of construction defect litigation?

2. What kind of construction defects spark the litigation? (PROBE FOR MOISTURE INTRUSION ISSUES) How important are each of the following?

- Landslide/geotechnical problems
- Design deficiencies of buildings and/or common areas
- Substandard/poor workmanship
- Deficiencies with respect to building materials

3. From an energy efficiency perspective, we have found residential construction defects to include primarily the following:

   a) HVAC installation and design problems

   b) Building Envelope: Defects in the installation of insulation are common, including voids, gaps, and compressions. Defects also are common in air and moisture sealing of the envelope.

   From an energy efficiency perspective, we have found nonresidential construction defects to include primarily the following

   a) HVAC installation and design problems

   b) Lighting Control Systems

   Which of these defects contribute to litigation costs?

III. Test Recommendation Components

We have previously concluded that the best way to address construction defect issues from an energy efficiency perspective is to promote building commissioning and "house as a system" construction practices.

What I'd like to do first is ask you to assess the pros and cons of each of the following recommendations from an insurance liability and/or construction defect perspective.

So, let's start with the first component **(READ 1)**. What are the pros? What are the cons?
Is this a viable recommendation in the marketplace – is it realistic?
How would you add to or tweak this recommendation?

1. ***Recommendation***: Require commissioning for all nonresidential buildings built in California. Commissioning process should include the following elements:
   - Commissioning plan at the predesign phase
   - Independent commissioning agent from outset
   - Customized test plan as part of project design documents
   - Review systems installation throughout and oversee functional testing
   - Operation and maintenance manuals and plans
   - Training plans
   - Final commissioning report for building owner

   Rationale: Maximizes energy efficiency gains, minimizes construction defects, and thoroughly documents construction process in the event parties involved are subject to a legal challenge.

2. ***Recommendation***: Require "house as a system" approach for all homes built in California. Process should include the following elements
   - Mechanical drawings as part of design documents required for building permit.
   - Performance testing of the ducts and HVAC system
   - One or more envelope inspections to verify quality of the insulation installation and air and moisture sealing.
   - Verification and documentation that all building systems perform interactively in accordance with the design documentation and intent, and in accordance with the owner's operational needs
   - Satisfactory inspection results and performance testing reports as precondition for issuing occupancy permit.

   Rationale: Maximizes energy efficiency gains, minimizes construction defects, and thoroughly documents construction process in the event parties involved are subject to a legal challenge.

3. ***Recommendation***: Document the non-energy benefits of improved construction practices through building commissioning and system approach to home construction. Data should be actuarial quality and should document benefits from reduced litigation exposure and callbacks.
   Rationale: Provides the financial rationale necessary to justify lower insurance premiums to builders and contractors who diligently apply building commissioning and system approach to home construction.

4. ***Recommendation***: Make sure that building commissioning and "house as a system" practices address building safety, security, and comfort as well as energy efficiency, and then market those building features.
   Rationale: Expands the potential non-energy benefits from building commissioning and "house as a system" practices.

5. ***Recommendation***: Offer a state tax credit for Green Buildings. To support a truly holistic Green Building program, convene a roundtable of state regulators to act as an ombudsman for a coordinated set of regulations supporting green building practices.
   Rationale: Green Building element expands the potential non-energy benefits from building commissioning and "house as a system" practices. Tax credit reduces construction costs.

IV. Other Recommendations

Last, what other recommendations do you have that would encourage the insurance industry to endorse or promote a systems approach to home construction and building commissioning, making them more of the standard?

V. Close

That's about all the time we have this evening. I want to thank you all for coming and brainstorming with me tonight – your input is very valuable. You can collect your incentives at the front desk.

D. INTERVIEW SUMMARIES

Module A. Construction practices in building quality and call backs

Summary of Findings

Residential envelope performance issues

Problems

- Water infiltration from below. In Fresno, a PG&E Comfort Home suffered from poor drainage. House was damp inside, had mold on walls and condensation on windows. "Comfort Home" was not comfortable, even though it was energy efficient. Foundation problems stemmed from expansive clay soils, which were inadequately compacted before construction, combined with inadequate footing depths. Foundation cracked, water infiltrated house, problems began.
- New insulation product is blown into the wall cavity wet. It must dry for 24 hours before hanging sheet rock. Contractors are not letting it dry, which causes problems with mold and rotting, including the sheet rock. The insulation product has also been found to corrode copper piping.
- Negative pressure can cause moisture to be drawn in to the home and cause rot and deterioration of the insulation. This occurs when the HVAC system is not operating correctly. Often, such problems can be linked back to the return air system.
- It is very common in older homes to find double-glazed windows with bad seals.
- Recessed down-lights create potential infiltration paths to the attic space or the buffer space between floors, which is typically vented to the outdoors.

Causes

- Insulation is "just slapped up where it will be seen." The R-value is usually too low or installers cheat by "fluffing" the insulation material to appear thicker. At least 50% of the jobs are done improperly. Walls are covered so quickly that the home owner will never see the problems. Inspection is often cursory. Inspectors spend very little time at a site.
- The problem isn't always insufficient insulation. There can even be too much insulation but if the home is not sealed correctly there will be inefficiencies. Sealing a house correctly is very important to the proper functioning of insulation.
- Lack of awnings and sufficient over-hang in home designs results in rain hitting walls and resultant moisture intrusion into the home.
- In new construction—buildings are getting really tight now, and so there's not enough airflow. That's an issue to air quality.
- Pressure differentials can cause back-drafting of carbon monoxide into the home.

Solutions

- Use building inspectors to adequately inspect attics for proper insulation.
- To prevent pressure differentials power vents should be installed to provide makeup up air.
- Improved framing practices can prevent areas (especially in corners) where insulation can't be installed.
- A diagnostic test is needed to find moisture problems before walls begin to rot. California needs to addresses moisture issues as a real problem in the design stage of a project.
- Options for meeting fresh air needs in residential construction include; separate fresh air intake with filter, integrate fresh air intake with central system with damper, use variable speed fans, install range hood and bathroom exhaust fans that run at all time on low speed.

HVAC performance issues

Problems

- Undersized duct runs cause pressure imbalances and increased infiltration when interior doors are closed. Most installers simply use rule-of-thumb type systems. Few HVAC contractors take the time to learn the use of ASHRAE Manual D or train their staff how to use it.
- Excessive duct leakage due to use of cloth-backed rubber adhesive tape, lack of mastic sealant, lack of duct diagnostics and pressure testing. One estimate is that 20% of projects require callbacks to address duct leakage. HVAC contractor claims leakage problems overstated because duct tests use pressures that greatly exceed operational conditions, thus over-estimating actual leakage rates.
- Incorrect refrigerant charge, which was identified as a problem in over 70% of installations nationally, is projected to increase cooling system energy use by 12% (Neme, Proctor, and Nadel 1999).
- Estimates of potential new construction energy savings available from duct leakage remediation efforts range as high as 25% of base-case heating and cooling energy use. (Neme, Proctor, and Nadel 1999).
- Poor terminal selection-floor registers used in ceilings, poor placement of terminals, which promote poor air circulation.
- Half the time, ducts are installed in unconditioned space. Insulating duct with R4.2 in an attic that's 130 degrees doesn't do much.
- Incorrect cooler size. Most installers simply use rule-of-thumb type systems. Few HVAC contractors take the time to learn the use of ASHRAE Manual J or train their staff how to use it.
- Using building cavities for cold air return (instead of conduits)
- Flex duct is supposed to be pulled tight, ridges cause resistance and this is increased if it is not taut. Duct can fold on itself if it's too slack. Few installers do it properly.

Causes

- Architects do not concern themselves with HVAC needs and consequently the necessary space for HVAC equipment and ducts is not designed into the home.
- Most builders are not aware of what to ask for in quality HVAC installations
- The consumer market has yet to drive the builder from an economic perspective--hasn't hurt builder economically to allow poor quality installations to continue.
- HVAC contractors don't spend any time learning about the updates to Title 24. They rely on the inspection process to "train" them, by catching mistakes.
- It's a design issue—with manufacturers. Commercial equipment is tested for climates other than California, so they are not optimized.
- Equipment sizing procedures assume ideal system installations, such as zero duct leakage (ACCA 1995). From the contractor perspective, oversizing of air conditioning systems has been the easiest way to minimize homeowner comfort complaints, which in reality are due to a myriad of problems including shortcomings in duct design, excessive duct leakage, inadequate air flow, and improper refrigerant charge.
- Limited training and lack of code enforcement on insulation installation quality contribute to a wide range of defects.
- Residential HVAC systems aren't "designed", this should be required in residential construction.
- Builders have developed a derisive attitude toward Title 24 and cheating is not associated with reduced energy efficiency, it's associated with not losing to the eggheads. This is counter productive for everyone.
- Most construction is done by poorly-paid migrant labor. You've got guys spreading caulk at the base of all wall framing because this is what the boss told them to do. They don't know why so the caulk goes on thin, fast, and not even in the correct place. This is a typical Title 24 requirement that just doesn't get executed as the guy who thought it up imagines.

Solutions

- Require ACCA design documentation air flow, refrigerant charge, and duct leakage documentation.
- Use independent 3rd parties to inspect 15% of all new construction, not just ACM-related homes.
- Test them—maybe not every single home, but some fraction at least that the builder is required to test.
- HVAC contractors resent third-party verification requirements in Title 24 ACM for ducts. Feel that third-party requirement does not resolve conflict of interest issues. Third party inspections are not required of electrical systems or of the structural integrity of a home. Prefer verifications handled by building inspectors.
- Provide incentives for equipment manufacturers, existing training facilities, ACCA, community colleges, and other qualified 3rd parties to set up training programs to handle the demand.
- According to an HVAC contractor, the building community is disgusted with the amount of regulation already existing. More would only serve to anger them further. Requiring HVAC contractors to be properly educated and trained would be a good thing in ensuring that the ultimate installations be done correctly.
- Building inspectors feel their relationship with builders and contractors is already antagonistic. Not interested in expansion of their "watch dog" duties.
- Make builders aware of the problems that result from a poorly designed, poorly installed system. Increasingly HVAC ends up being included in construction defect litigation. This has drawn many builders into court where it is obvious that they totally dropped the ball on ensuring that the HVAC installer was doing the right thing.
- Invent a quick, effective, and reliable mechanical duct seal. A new, simple design would be a great asset to builders and inspectors.
- Investigate using fiber glass duct systems which sufficiently seal on their own.

- Require R8 insulation on ducts in unconditioned spaces.
- Regulations must be simple and easy to follow. There should be broader categories of changes so that the impact of changes don't trickle down so far. Rather than 5 changes creating a matrix of 100 possible mixes, matches, and requirements, those changes should create just 10 possibilities. If 3% energy efficiency is sacrificed but adherence is doubled, then everyone wins.
- National Survey System provides surveying of new home buyers. The results are published by builder. Developers are rated based on their customers' feedback. HVAC is a big area of interest. This kind of program would be great to publicize contractor performance.
- Programs such as IQ+ are a real boon since they defer a bit of the cost for providing a high-quality, well-running HVAC system.
- California Pacific Homes uses 3rd party inspectors to check out insulation installations. Over time, subcontractors get nailed often enough that they learn to take it more seriously. Testing with thermal imaging proves effectiveness of good insulation job.
- Good public relations value can be realized by building owners if they can announce that the building has been recognized for its efficiency. For example, a local WalMart store has a large sign that indicates the EPA has recognized the building with an Energy Star award. Such PR value can be very seductive to building owners.
- A builder must operate in the open market. Only those factors that are deemed important to customers will be addressed. In Las Vegas, builders routinely offer guarantees to home buyers that their utility bills will not exceed a certain amount. This is due to the fact that energy costs comprise a relatively higher percentage of a home owner's budget and are therefore a concern to them.
- No "carrot" would be big enough to change insulation practices. Only a stick will work on these guys. Thorough inspection should be required by someone who knows what a proper installation looks like.

- Contractor licensing board needs to make penalties for improper duct installations. They should take more of a policing roll. They used to do this within the industry years ago. Title 24 is viewed as onerous and unnecessary. However, if the licensing board could be involved—used as the "stick—then the policing would be coming from within the builders' own community and might be better accepted.

Nonresidential lighting performance issues

Problems

- Occupancy sensors have become somewhat unpopular because of their potential to turn off lights while the space is occupied. In the field we found a great majority of people removing and or over-riding the sensor due to poor functionality." (RLW Analytics 1999).
- The location of sensors if critical to proper performance of lighting control systems. They can miss people in cubicles or bathroom stalls, for example, and can shut the lights off at inopportune moments.

Causes

- Calibration issues are the most common problem. Users get disgusted and over ride the systems. It is very uncommon to find a working system that has not been tampered with.
- Improper design of and use of sensors. Location and proper functioning are very important.
- Lighting is designed late in a building project (it is usually left as tenant improvements).

Solutions

- Developers and building owners should be educated about the benefits in performance and operation of quality lighting. They must start demanding it for the market to change.
- Use "zone" control systems that operate based on a timed setting and not sensors. Such a system can not be easily defeated by occupants but can still be over-ridden when lighting needs change.

Module B. Diagnostic testing and performance testing for residential buildings

Summary of Findings

Value testing residential building performance

- Testing can reduce litigation and this is potentially big benefit because 60% of litigants win. $100's millions construction defect cases lost in San Diego County. However, there is not enough quantitative data on benefits to reduce insurance premiums.
- Testing improves customer satisfaction and consequently builder reputation
- Testing teaches builders how to fix their own problems. They know right away when something wasn't installed properly and can learn right then and there, so that they don't repeat the problem in the next installation.
- From the buyer perspective it improves home quality. Without testing certain systems, consumers don't know whether they are working. Some systems have to be tested to prove they work, not just looked at.
- It seems that testing for standard production homes may not make a great deal of sense. But testing for large custom homes should simply be required. The potential for large energy savings and the chance that the unusual home might harbor unforeseen problems makes them a much better candidate for testing.
- Production builders cranking out houses in high volume are a real problem. It you don't impact their building practices they will crank out hundreds of sub-standard homes. They can benefit greatly by testing if it shows them their practices are faulty and if it prevents them from being sued by unhappy home buyers.
- Testing is a fairly crucial and untapped resource. The quality of installation (HVAC) is a result of poor and non-enforceable standards. And, to assigning bids or rewarding contracts to low-bidders.
- Testing is a quality assurance mechanism. Buildings are too complex these days. Checklists and visual inspections don't cut it anymore,

especially when you're dealing with building envelope issues, things you can't see.

- In new construction someone who buys a house that's been tested is assured the quality is good and they are getting what they paid for.
- In retrofit, there isn't really a design aspect. So with diagnostic testing, you can figure out ahead of time where you can make improvements.
- Until we're able to raise standards of contractors we deal with daily, the only way owners know if they are really getting what they are paying for is by testing.

Road blocks to increased use of testing

- Builder's downside is that energy efficiency cuts margin. Builders not willing to increase sale prices to reflect increased construction costs. Builder starts out at the subdivision planning stage by identifying the home features needed to sell to target market and the sale price the market will bear for those features. Designs and builds homes to those benchmarks. Energy efficiency not on list of home features customers want so can't increase sale prices for efficient homes.
- Lack of understanding by builders. They don't see benefits of residential diagnostics, the benefits haven't been explained; there is no buyer demand.
- Lack of contractor certification. Push for certification is gaining momentum through Air Conditioning Contractors of America (ACCA). Need 3rd party trade schools help train for certification tests (and manufacturer schools)
- Lack of awareness of the energy benefits and long term economic savings benefits
- Lack of understanding of impact on indoor air quality, moisture control, health and safety. Still need more R&D. Some report that IAQ not a high profile issue or barrier. Maybe in Southeast or other more humid climate.
- Lack of standardized methodology and testing procedures that would make the process of diagnostics more efficient, cost effective and accessible and making this information available. There are no

standardized procedures, but not really sure we need this. The government would then have to be involved, and they are already involved.

- Need better (more uniform) standards relating to air pressure balancing (safety issues) and air flow and refrigerant charge. CEE is assembling "national" standards on installation. PG&E working on uniform standards for installation quality
- Lack of consumer demand and cost. Ultimately the homeowner has to pay for it. They already assume the cost of installation should cover correct installation. Why should they pay more to test something that should be inherent in the cost? The idea of selling energy efficiency as an upgrade to a house seems absurd. Consumers expect the systems to work, so how could you sell it as an upgrade?
- Lack of infrastructure to support it. In SoCal, list of qualified raters is small (except in San Diego Co.). Timeliness is critical but builders cannot be certain of existing raters' ability to inspect construction projects without interrupting work flow.
- Lack of awareness of who the service providers are. And even if they do figure out WHO they are, the owners don't trust them. It's a perceptual thing. Builders have to have an established relationship with testers so that they don't feel like their work is being second-guessed.
- Lack of awareness of potential to avoid liability, callbacks, litigation. Some claim that Liability issues related to multi-family but not single-family.
- Potential for project delays and perception that testing is costly
- Tests reveal defects from the point of view of the builder, it's a lose-lose situation. Unless there is a benefit to them, benefits such as marketing, he can charge more, or a code requirement. Can show them the benefit of reduced call backs and how to avoid them since they are costly.

- Additional Costs, not just first costs but the costs of marketing, getting the work out to your customers Those costs add up. Also, if builders have to include the cost of testing in their bid, it makes them less competitive with other builders who don't use it and have lower costs. The bottom line always wins.

- Lack of financial incentives, awareness to builders that if they spend more on testing, they might save money in installing lower ton AC, for example.

Trends in testing

- The preponderance of diagnostic testing and third party inspections currently being conducted on residential construction is done in association with energy efficiency programs administered by a utility or governmental agency.
- Construction industry needs to adopt systems approach to design and construction, which includes incorporating mechanical design of the HVAC and ducts in the blueprints, making sure designs were followed, and performance testing.
- Diagnostic testing is a growing business. ConSol is having success selling testing services as part of ComfortWise. Participating builders include Lee builders and Suncrest. ComfortWise has 6,000 homes in pipeline. ConSol hopes for 20-30% of the market. On another positive note, on-site training in diagnostic testing completed between 1995 and 1998 in California and Nevada was very popular with builders and their subcontractors. Contractors who thought that they were installing tight ducts could see where and how much leakage was occurring (Buildings Industry Institute and ConSol 1998). Apparently, as the level of knowledge increases, so does the level of appreciation for diagnostic testing.
- Testing is not used, or rarely used in new construction. It is used in problem houses, but there is less money being put in by the utilities and there's less incentive for people to test. There are not a lot of new programs. Rather, people who practice energy efficiency practices are comfortable with it and just do it as common practice.
- Simulation results indicate that the most cost-effective energy efficiency measure is the reduction of outside air infiltration. A number of varying steps can be taken to reduce outside air infiltration, however, the effectiveness of all of them can be measured using a blower door test

(Wirtshafter and Hildebrandt 1992). Another study indicates that 30% to 40% of residential HVAC energy consumption is lost through leaks in the ducting system due to poor installation (Syphers, Lekov et al 1998). Duct tests are also among the most widely discussed in the literature. The need for diagnostic testing of ducts is underscored by the wide variation observed in duct system efficiency and envelope leakage levels in different houses (Wray, Piette et al 1999).

- To reduce upgrade cost concerns, need to be able to demonstrate that higher construction costs translate into higher sale value. Some builders say they could build crackerbox houses and sell them. However, "If price were the only factor, everyone would drive a Yugo"
- 1999 Surveys of Homebuyers regarding energy conservation found they ranked the importance of green buildings way down the list. The future of performance testing requires a considerable awareness campaign on an ongoing basis. Performance testing is important in SoCal because territory load growth is occurring in areas with big cooling load. In the absence of consumer demand, utility support needed to develop builder and contractor awareness.
- Full impacts of T-24 ACM changes yet to be seen. Changes went into effect 7/1/99. Builders pulled lots of permits prior to that date. Many of those homes are still under construction. With more projects with post-7/1/99 permits come on-line, could see increase in duct testing for ACM credit.
- Testing is growing, but does anything happen as a result of this testing? No.
- The use of testing is increasing slowly There is increased awareness from state energy offices.

Solutions to improving use of testing

- At present, builders don't see value of diagnostic testing. They need; education on how changes improve their, training on how to market benefits of higher quality homes, and documentation showing increases in sale value, reductions in liability.
- Need to compile data on the effects of diagnostic testing on the speed of home sales and their sale value.
- Selling diagnostics as energy efficiency program just doesn't work. The cost is seen as to high even though it is relatively low. To get it off the ground, testing should be free and concentration should be placed on showing that building quality issues are prime concern.
- Cranking in more specific regulations about each element of a house isn't going to help improve efficiency. What needs to happen is that Title 24 specialists be included in the building process from start to finish. Currently, plumbers must guarantee their work but not Title 24 specialists. They sign off at the project's beginning and that's it for them. Structural observation should be required of Title 24 specialists so that they ensure the project adheres to their original plan.
- Codes must be simplified and developed to be easily understood. Builders are not sophisticated people and complicated calculations turn them off very quickly. The goal should be to change building practices so that the "norm" meets increase efficiency standards.
- All-in-all testing is great in theory but will only cause more resentment among builders. Effort should be expended to simply the energy codes and keep in mind that builders are not engineers and that the energy consultants who sign off on the original plans are not around to see how the project develops.
- It is important not to alienate building community. Too often in the past the energy efficient concepts are handed down from on high by scientists who are very sharp people and have very creative ideas but who have no clue as to the culture of building. It is very important for builders to have consistent and predictable techniques. Too often, regulations have exceptions and special circumstances. Often, these really don't matter

much. Builders are not anti-efficiency but they are anti-hassle. If the hassle factor is perceived as high, then you lose buy-in by the builders.

- Utility support important at first. Support necessary for 3–5 years? Phase out incentives over time.
- Conditions for withdrawing utility support: established testing infrastructure, mechanism for continuing education, demonstrable benefits, lower cost of tests.
- Mandate tight ducts in Title 24. Home builders resist changing construction mandates in middle of projects. Could incorporate testing in new projects.
- 3rd party inspections may not be essential. Expect minimal cheating on legal documents. Could have HVAC contractor or builder do testing as long as there is the potential for audit/QC inspections. SCG's past QC inspections have found good compliance with T-24.
- Need; testing equipment, tool lending program, field training, feedback loops from diagnostic tests to designers, performance guarantees, Energy Star rating to draw consumer interests, multi-stage inspections/ratings, 3rd party inspections
- Tax credits for diagnostic testing.

Linking of testing with other energy efficiency programs

- PG&E reducing incentives over time. For sustainability, programs need consistent construction quality, quality assurance mechanisms. To reduce participation hassles: PG&E is developing Pilot local government programs. Benefits to builders include expedited plan checks, reduced permit fees, and possibly electronic paperwork filing.
- Home labeling can be important stimulus to promote more widespread testing. Labeling is needed as a consumer information mechanism. It is also useful for resale, Financing, EEM’s. In New England, the Energy Star program has grown considerably in the past couple of years. It involves testing and they are seeing/counting on 10% growth/participation in the program. This program includes diagnostic testing.

- Current initiatives include; training programs, ComfortHome and Energy Star Programs, ACM (Builders not yet confident in compliance credits for compliance. They are concerned about risk: what if it fails test?)
- The Building Industry Institute (ConSol) is developing the *Community Energy Efficiency Program* in partnership with the local governments.
- CEC endorsed program. Utilities can support through 3rd party initiatives program (TPI).
- Requiring diagnostics in energy efficiency programs would be a big bonus.
- HERS ratings could include diagnostics. Make sure to require HERS ratings in Title 24.
- It should be a standard. If you change standards from prescriptive to performance, then can expand diagnostics by linking them with building standards. Having both puts in a double-hit, and then there's lots of market resentment.
- Definitely opportunity to expand residential building diagnostics by linking them with insurance or liability options. With the increase of the rise of allergies and asthma energy and energy efficiency can be linked with everything, especially due to things like air quality, comfort, increased productivity. Also, linking testing with insurance or liability options would give owners an advantage due to having a better, safer and healthier building.
- Utilities can be advocates by providing marketing collateral. They maintain a staff that works with builders to get them to build better.
- Builders should be required to take classes on building systems, construction techniques, and energy efficiency. It is way too costly in time for city officials to be educating builders about Title 24 issues. The mind-set among builders is "but we've always done it this way." This must be changed but it has to happen from within the construction industry if it's to be effective. They'll hear the message if it comes from their own side.
- Linking testing with some sort of home warranty system would be great.
- Not national programs. The Energy Star stuff is a complete waste of time.

- Offer a "comfort guarantee" through the use of diagnostic testing. Offer a QC process for builders, eliminate call backs (costs of) by making sure HVAC systems work.
- ASHRAE should back commissioning and encourage it.
- Offer better energy rates for homes that are diagnosed.

Linking of testing with insurance or liability programs

- Not worth it. A total waste of everyone's time.
- If the HERS rating involved diagnostics the insurance industry would find that useful. Especially with respect to indoor air quality issues.
- Insurance companies might consider paying for the test. The market will work out who should pay (for diagnostic testing).
- If builders can show they are taking steps to lower litigation costs, then everyone would benefit.
- Fire insurance, homeowners insurance, and health insurance should be linked, especially with envelope issues.

Module C. Building commissioning and performance testing for nonresidential buildings

Summary of Findings

Value of building commissioning

- Effective commissioning of building HVAC and control systems has been increasingly identified as a major factor in ensuring the energy effectiveness of the building. Proper commissioning reduces energy consumption, increases occupant comfort, improves indoor air-quality, and lengthens life of equipment (O' Neill and Radke 1994). Significant amounts of energy are wasted each year in commercial buildings due to inefficient operation of HVAC equipment. Increased energy consumption of 10–35% is not uncommon due to what appear to be minor adjustments to equipment and controls (Waterbury, Frey et al 1994)

- Owners and facility engineers engaged in the design and construction of buildings all have horror stories about buildings with serious flaws upon occupancy. One of the most common complaints is of HVAC systems not functioning correctly. Annoying problems such as unreliable temperature controls, overheating and overcooling of various zones, lack of credible air-balancing, absence of building pressurization, and poor documentation continue to exasperate the facility engineers long after the building is occupied (Tseng 1994).
- Mentioned sources of value from commissioning include; verify construction quality, system installation quality, reduced call backs, improve customer satisfaction, establish baseline to measure subsequent performance, improve air quality, influence standards development and construction practices.
- Whole building commissioning may not have value for new construction. In California, building shell is minimum influence on energy use due to mild climate. There are performance issues with static systems (windows, insulation, etc.) but they only need to be inspected at time of installation. After that, there is no need to look at those systems again. Inspection of static systems is independent of commissioning activities.
- Commissioning of lighting can be independent of HVAC and should start at system design stage, continue through implementation, feed back into next project.
- Commissioning on buildings at Texas A&M found that they saved 28-50% on average in some situations.
- Many building owners don't have expertise to know whether something was installed correctly let alone functioning properly, testing can locate these problems.
- Commissioning allows accountability and documents design "intent" so your end result mirrors what the initial design was and you can then see where the breakdown was.
- Provides feedback too for construction team so they know where the problems exist, documents the front-end information and reconciles it at the end.

Why building commissioning is not used more often

- Given current construction design process, the handoff between many players means that you lose accountability.
- Additional project costs associated with commissioning
- Lack of financial incentives
- Builderd don't budget for it, they don't see commissioning as part of the construction process.
- Lack of awareness of the energy benefits and long term economic savings benefits of commissioning
- Commissioning is not an easy concept to understand. Everyone says they do commissioning their buildings, but really they aren't. There is no real 'definition' of commissioning.
- Who are the service providers, lack of quality assurance
- Lack of a standardized methodology and testing procedures
- People really don't know about it, especially building owners. All of the market actors need to be informed so that owners can ask for it because they understand the value in asking for it, and likewise, builders and developers and offer it or push it, because they understand the value.
- There is a strong lack of expertise, a lack of infrastructure. There is a general lack of training for those conducting the commissioning. There is a lack of knowledge of what to test and how to test it.
- Skepticism on part of building owners and managers
- Extra time and paperwork associated with the commissioning process
- Lack of mandates enforcing building commissioning
- Commissioning has been reintroduced as something that can only be done by a commissioning agent and this adds yet another layer to the already fragmented construction process. Public goods programs in the first years have positioned utilities as being more credible than people who actually build/design. This is a barrier because now people don't trust the service providers. About 15 years ago they [the utility] responded to

poor quality construction. So they positioned themselves to be a barrier to the market by solving their own problems. Commissioning advocates need to "pass on" on their knowledge to facilitate the market, not carry it.

- Buildings now are incredibly complex. They have much more sophisticated building systems, so really commissioning should just be a natural component of the process. It used to be that EMS accounted for 10% of the mechanical budget for a building, it's now close to 20%. However, these systems often are compromised by poorly-trained operators and changing building conditions. But building owners just don't see the value and they don't think they should have to pay for something that should be included in the initial purchase (the assurance that the systems are installed properly).
- Controls are put in and then they are never exercised whether they were installed properly. They are usually installed the same for every building, however, with the more sophisticated buildings now, you can't do that anymore. You need to customize the controls. Controls contractors make it so that the owners 'need' them. The set up a service/maintenance contract that locks them in. More money, less incentive to install correctly the first time, and certainly less incentive to train any sort of maintenance staff how to test.
- Upfront costs. The owner representative doesn't know what commissioning entails and it is hard to agree on metrics of the benefits. They are still trying to formulate exactly how much can be saved. Building owners in MA have to pay for a structural engineer to be on-site witnessing structural systems being installed. Budgets are getting tighter and project management usually gets cut because it's too expensive. There is an incorrect assumption that there is nothing that can be done about construction project budgets. With the bidding process there is an inherent problem of cutting 'value' and not being able to sell quality.
- IP M&V Protocol overly expensive standard for testing. Simpler protocols would address majority of problems with minimal effort. Need simpler M&V tools and procedures to make commissioning affordable. commissioning advocates want expensive M&V to avoid risk.

- No one wants to take responsibility for building performance problems. No one wants to be liable.
- For new buildings, people feel like they would be paying for something they should be getting already.
- For existing buildings, people aren't getting results they should. Need to pay more attention to design and intent. People have to be willing and able to change both their thinking and their systems.
- Because people have decided over the last 50 years that they don't want to change don't realize how sophisticated buildings work they are still using old practices, and are not being educated on new ones.
- Everyone has their role in the process, and commissioning gets involved and can disrupt the construction process, or they think it will. People are afraid that the only purpose of commissioning is to catch problems. They don't realize the benefits until they see them.

Trends in commissioning

- Estimates suggest that less than 5% of all new construction and less than 0.03% of existing buildings are commissioned each year. (Dodds, Dasher et al 1998). Even though building commissioning has yet to become "business as usual", there is a significant resurgence of interest in commissioning and recommissioning of buildings, which is being driven by energy efficiency and indoor-air quality (Claridge, Haberl et al. 1994).
- There seems to be more and more instances of case studies and success stories. At the National Commissioning Building conference every year there are more participants. It's not just a small group.
- It's finally growing because technology is improving. Some systems now you have to commission just to make sure they work, not just whether they are installed properly or to function most efficiently.
- People are beginning to understand how and what it means to commission a building. People are learning about it through workshops such as PG&E's, trade journals, ASHRAE, commissioning conferences, IAQ, people are just talking about it more.

- Commissioning has historically been done for buildings that have complex energy systems, high energy use, or for owners who value a high quality of indoor environment. Examples of such building types include government buildings and complexes, hospital and healthcare facilities, large commercial buildings, universities and owners who are responsible for establishing on-going building programs. (Dodds, Dasher et al 1998). Big companies, like Genentech, for whom system performance is critical, now practice system-level design and commissioning on a routine basis.
- There is an opportunity for improved energy efficiency in the retrofit market. Property management firms and real estate holding companies have an interest in reducing operating expenses and can often be interested in improving their buildings.
- It is a growing practice. Those who try it seem to always be happy with it.
- The trend was that it was growing before the code required it (in Seattle). It was put into code because is was happening all the time.
- It is a growing industry, but it's not marketed. So, people really don't know about it. Once we have enough case studies, that will serve as proof that they really do work.

Road blocks to commissioning

- People who operate the buildings are committed but they aren't aware of improvements so it's hard for them to first even think of someone from outside and then letting this "unknown" or unfamiliar person tell them what to do or how to run their business.
- People need to understand the benefits so they will spend the money on it. Too often the owners and even the builders don't really feel that commissioning adds that much value, so they are not willing to pay for it.
- There is a perception of low increased benefits by commissioning. Builders and owners need to be shown the benefits.
- Lack of awareness of the energy benefits and long term economic savings benefits. Builders especially see commissioning as an added cost and are not sure what it will do for them. However, once they experience

commissioning, they are very happy with it. He has not heard of anyone who was upset by the commissioning process.

- Lack of a clear understanding of what building commissioning implies. Everyone says they are commissioning their buildings, but the problem is that everyone has a different idea about what commissioning means. So, while some may think they are commissioning, really they aren't.
- Extra time and paperwork associated with the commissioning process. Builders seem less willing or are skeptical b/c it's sort of like questioning their work. This is related to the first barrier, why should they take the extra time to do something that they aren't sure is beneficial?
- Additional project costs. By the time everything is designed, commissioning is the last to be done, and usually all the $$ is spent. If there are $$ problems, commissioning is the first to be cut. This again goes back to quality; people don't see the value of commissioning.
- Lack of a clear understanding of what building commissioning implies. You can commission certain systems, or the whole building. We don't have any sort of guidebook or handbook on costs of commissioning, and/or what commissioning implies. There is no consistency.
- Lack of education among contractors. They have old habits and they aren't really seeing the value of change.

Policy options for expanding the use of building commissioning

- If commissioning were incorporated into state and federal agency programs it would increase the application of it (people would have to use it).
- They should put out a handbook that tells exactly when/where/how commissioning should be within the construction process.
- Need to have qualified commissioners
- Certification for building commissioners by state. Maybe let private sector handle this but maybe have the code define what is expected by commissioning.

- Design an internship program to provide commissioning experience to engineering students and recent graduates
- One idea is to give out certifications for commissioners, make them more reputable, and add standardization.
- Introducing commissioning into the standard curriculum for architecture and engineering programs.
- Developing one-day lesson plan materials for commissioning to increase the likelihood that faculty would include commissioning in their course work (Dodds, Dasher et al 1998).
- Need an important "leader" or champion in commissioning. Need a cheerleader and local government buildings are a good place to start = commission them, and then show how it has improved their performance.
- Initiate studies on costs and benefits of building commissioning, including a quantitative cost-benefit analysis of commissioning relative to 'non-energy' benefits, such as improved air-quality, better work environment resulting in higher productivity. (Dodds, Dasher et al 1998).
- Most of the strategies for overcoming the market barriers could be enhanced by involvement of the Federal government to promote commissioning through marketing efforts, provide funding for commissioning, demonstration projects, cost-effectiveness studies, develop a commissioning curriculum for engineering and architecture programs, requiring commissioning of all government performance contracts-- especially for military bases
- Incorporating commissioning into current energy programs, such as EPA's ENERGY STAR Building and Labels programs and Green Building's program
- Developing metric for measuring the benefits of commissioning as part of DOE's International Performance Measurement and Verification Protocol (Dodds, Dasher et al 1998).
- Tax incentives or other financial incentives were identified as an important strategy that the Federal government could use to encourage building commissioning (Kunkle, York 1999).

- Some participants noted the need for additional commissioning information (guide specifications, commissioning plans, guidelines, test procedures and RFPs) for commissioning providers (Dodds, Dasher et al 1998). Common training material developed by the Association of State Energy Research and Technology transfer institute with funding from U. S. DOE was successfully used in the Northwest and Wisconsin (Dodds, Haasl et al 1994).
- Commissioning should be more than tweaking installed systems to meet system performance requirements. It should start at the design phase and look for opportunities to optimize performance through the installation process. The key intervention often involves getting the mechanical engineer on the right track to design an energy-efficient system.
- Leave commissioning to private market actors. If we let “quality performers” do the commissioning themselves, they will do it, and they will do a good job. Many of the quality contractor firms will learn how to commission simply to carve out their own niche and make a name for themselves as quality builders. They will use it as a selling feature for their services.
- The solution to getting more buildings commissioned is to educate the owners and standardize the commissioning process in general. This can be done by involving ASHRAE, and PECI.
- The Alliance determined the best place to focus an educational program was on A/E firms, since owners trust them and rely on them the most.
- Offer small incentives for testing rooftop units
- Simplify the M&V protocols required. Simpler protocols would allow the industry to capture 80% of the benefits with only 20% of the effort.
- Develop simpler monitoring equipment and software for analysis. Need to automate monitoring activities. Need data mining tools to sift through mounds of useless data to find the informative nuggets.
- Third party initiative program gives smaller contractors and independent firms a chance to learn about better marketing skills and about building “tune-ups” or recommissioning.

- Utilities should include commissioning as an element in all programs. Retro commissioning is more important than new construction.
- Commissioning can be easily linked to measurement and verification. However, existing M&V requirements drive up project costs, add paperwork and hassles, and are unnecessarily complex for most potential projects in the field.
- Air quality and productivity issues provide particular opportunities to link building commissioning with insurance liability issues. Quantifying those links will be difficult. However, insurance industry executives have already shown interest in funding additional research, though they may not yet be ready or willing to lower rates for commissioning.

Opportunities to expand building commissioning by linking it with building standards

- Make it part of the code. It's a good recognition of value of commissioning (by including it in the code).
- In the building standards arena, use performance compliance methods to promote commissioning activities. Could offer multiple credit levels. However, requiring commissioning would make problems.
- Our view of commissioning goes beyond just making recommendations for chance. We include implementation. We help building managers implement and show them how to maintain.
- It sort of is already linked, ASHRAE has guidelines.
- ASHRAE should back commissioning and encourage it.
- If buildings are commissioned they have proof of being better buildings. They should have lower insurance/liability. The quality of the building is better.
- If you're doing performance contracting clearly commissioning should be part of that. Anytime you're providing an incentive, you should make it a part of it. Also, in new construction, commissioning is the only way to make sure the building is energy efficient.

- It could be applied to any program, once it is recognized universally. Could even link it to ISO2000 (reduce emissions).

Module D. Energy efficiency financing (energy-efficient mortgages, performance contracting, building appraisals, etc.)

Summary of Findings

Benefit to lenders for offering energy-efficient mortgages

- Properties that they finance will become more desirable. It will increase the value of the home.
- They stand to benefit simply from larger loan sizes. The measure of success is higher loans = they make more profit.
- The benefits are not that great, and certainly not that obvious.
- The small benefits from increased loans. The profit is small, and there's not enough volume to pique interest.
- Lenders can use EEMs as a sales tool to differentiate themselves from others.
- Projects are much larger, so profits are greater
- The payback is often faster since larger buildings, but of course, not fast enough for some owners.

Reasons why lenders might not offer EEMs

- Real estate professionals are not very informed about the availability of EEMs and how to use them in marketing real estate.
- Misperceptions and misunderstanding of the market on the part of allied industries; e.g., consumers are not motivated to participate in energy-efficiency programs, energy-efficiency improvements are too costly, and that processes involved are complex and slow.
- Lack of adequate funding to successfully market EEMs to consumers

- Increased paperwork, energy efficiency documentation creates additional paperwork and can slow a loan process already overburdened. (Verdict 1996)
- There is a perception that EEMs require a lot more paperwork than they actually do.
- Commonly used lender and real estate forms do not convert readily to include financing of energy-efficiency products
- Non-uniform energy ratings are a problem. Mortgage lenders demand uniformity when packaging loans for resale. Unfortunately, there are numerous rating approaches, including performance and certified ratings that contribute to the lenders' aversion. (Verdict 1996)
- Perceived risk--the secondary mortgage lenders have little enthusiasm for energy efficiency loans because of the increased potential for loss if the loan defaults (Verdict 1996)
- Increased Risk. The increase risk about whether the technologies, especially the newer ones, will actually yield enough savings to increase the mortgage amount.
- Small profit potential , lenders do not view energy efficiency financing as a profitable lending area due to overall weak consumer demand. (Verdict 1996)
- Financial incentives, without an EEM, purchasers can borrow no more money for a very efficient house than for one meeting minimum code requirements, although one may cost hundreds of dollars more. Additionally, utility DSM rebates for more efficient heating and cooling equipment, insulation, lighting, and appliance are nearly gone.
- EEMs do not yield enough profit nor improve customer satisfaction
- Appraisers don't consider energy efficiency improvements in assessing home.
- Need cooperation from lenders, realtors
- The program has not been very successful. It hasn't even put a dent on what it could be. In new construction efforts have been admirable; but the market is really in retrofit and this needs to be addressed.

- The approach to the program—to target the lenders—is "logical" but not working. People who were pushing loans weren't educated, so they didn't really push the benefits.
- Realtors are not interested because auditors come in and have to deal with disclosure issues, it jeopardizes the sale. So, the program really hasn't gone anywhere.
- Uncertainty about true energy savings. The (newer) technologies are not really provenso there is general skepticism. He is not really sure of what diagnostic testing entails, so he's uncertain whether it would alleviate this problem.
- Most builders are not aware of the benefits of EEMs. Resnet.com did a survey where they hypothesized that 100% of those applying for home mortgages would have received $5000 more through an EEM.
- Most lenders don't really care about energy efficiency. Their bonuses are tied to the bottom line ($$). That is why a lot of energy efficiency projects don't go through. Energy Efficiency is not valued as important.

Policy options for expanding the use of EEMs

- Development of uniform, national home energy rating guidelines; increased competition in the banking, housing and utility industries; establishment of new, industry-based, support organization for HERS and EEMs; and, a shift in the Federal roles of DOE and EPA from one of a regulator to facilitator.
- There have been numerous industry-based groups established, dedicated to removing market barriers, promoting energy financing, helping to create other rating organizations, and promoting energy ratings at national and local levels.
- Federal agencies seem to have shifted their focus from being regulators in the 1970's to facilitators in the 1990's. With the establishment of the Energy Star Homes program, for example, EPA is working to promote efficiency and increase market demand, rather than simply regulate what efficiency guidelines and standards should be.

- Certifications for products they install (e.g., HVAC contractors), making them test for and receive a certification at the federal level. This would also ensure common best practices.

Opportunity to link EEMS to other energy efficiency programs

- It helps to share information with other agencies and try to coordinate efforts to send a consistent message versus just competing with each other.
- Energy audits. It's really in the marketing. Everyone agrees on the benefits of having a better home. But you have to get people asking for them.
- Yes, there has been a pretty good track record with the voucher program (in Southern California they targets low income households—provide vouchers for energy efficiency upgrades).
- Absolutely, you can tack loan programs onto utility programs and advertising.

Reasons that financing EEMs is difficult in the nonresidential sector

- Lenders perceived increased risk.
- Building owners, ESCOs, or lenders uncertain about true energy systems
- Lack of lender awareness of the benefits of energy efficiency
- Business focus on increasing revenues rather than reducing costs.
- Energy efficiency not meaningful to lenders
- Appraiser lack of awareness of energy efficiency not an issue for financing commercial projects. Commercial property appraised on basis of net operating income. Energy efficiency implicit in net operating income calculation.
- Quick paybacks, or lack thereof (perception of slow payback)

Can building commissioning alleviate this barrier?

- Appraisers don't consider energy efficiency in assessing building value. Appraisers don't report energy in their report. To some extent commissioning would help. They need to have a detailed approach on how to measure energy savings correctly, and commissioning would show this. The commissioning process could supplement a paper calculation, then an appraiser would be more convinced about overall energy savings.

- Lenders have difficulty selling loans on the secondary market. Again, there is no current secondary lending market, so not sure how commissioning can help that by itself.

- They've used commissioning as a "demonstration" type project as a tool to get financing. They show people exactly what/where they would save money.
- For the most part however, no. Don't think commissioning would alleviate these barriers. Those occupying the space are usually not the owners, and they not pay extra for something that benefits the buildings. The owners, however, might care more.
- Adding the cost of commissioning (usually around 3% of the total job) is a hard sell. The builders are skeptical of the benefits.
- With respect to lenders, barriers can not be overcome with the types of programs we've seen in California. Must convince lenders that there is value in commissioning; that it makes sense from a financial point of view.
- In some cases, lenders have said they need simple tools that simply measure and then they need to be able to compare their building against other buildings. There needs to be a baseline and a way to compare that baseline to make sure it if meaningful.

Policy options to expand availability of financing for energy efficiency projects

- Policy intervention at the level of the national appraisal foundation. They are working with them already to put in uniform appraisal factors. If energy is introduced, it would overcome some of these barriers.

- One policy option they are considering now is that of the Wall Street Initiative. This would be to standardize the way appraisers report line items. They want to add energy at a cost per square foot level.
- Appraisers, unlike other market actors, operate under standard rules, forms, etc. There is a lot of leverage there to introduce such things as energy into policy options.
- Federal tax incentives should be offered for energy efficient homes that are verified by the HERS rating.
- Appraisers are there to look at the overall financial picture and energy is just one part of that.

Opportunity to expand financing availability via publicly funded energy efficiency programs

- Yes, but it's hard to get funding to do that. But there is definite interest, that's for sure.
- I would think it is important that the CEC require HERS ratings.

Opportunity to expand financing availability by promoting building commissioning

- This may take subsidizing to encourage people to do that. If you pay for commissioning, or help pay for some of it.

Module E. Insurance/liability issues related to construction quality

Summary of Findings

Relationship Between Energy Efficiency and Liability Concerns

Types of liability insurance related to energy efficiency include:

- *Completed operations liability:* This insurance provides coverage for bodily injury and property damage arising from completed or abandoned operations, provided the incident occurs away from premises owned or rented by the insured. The best way of avoiding these problems is making sure the equipment is designed and installed properly, the focus of building code development and compliance, as well as standard measurement and verification protocols. In addition, because indoor air quality illnesses can result in large insurance losses, reducing the strength of indoor pollutant sources is commonly the best method to reduce indoor air pollution.

- *Comprehensive general liability:* This insurance means that the insurance company will pay all sums the insured becomes legally obligated to pay as damages due to bodily injury and property damage.
- *Contractors liability:* Contractors are liable for damages resulting from bodily injury and/or property damage caused by an insured peril and arising out of the ownership, maintenance, or use of premises and operations in progress. They are also liable for bodily injury and/or property damage after their work is completed and they have left the job site. This type of insurance covers people who are working on a particular construction site, in contrast to professionals who may not be at the construction site (e.g., architects and engineers). Building code development and compliance, measurement and verification protocols, energy management and control systems, building commissioning, as well as reduction of indoor air pollution and radon resistant housing are all examples of how this insurance loss can be avoided.
- *Product liability:* Product liability is the liability for bodily injury or property damage incurred by a merchant or manufacturer as a consequence of some defect in the product sold or manufactured, or the liability incurred by a contractor after he has completed a job as a result of improperly performed work. Building commissioning is a process that should reduce product liability claims by making sure that equipment (and the building) is operating as designed. Energy-efficient torchieres (instead of halogen torchieres) represent a specific technology that will significantly reduce product liability claims, since halogen torchieres account for about 10% of residential lighting use in the United States.

Insurance benefits to be gained by better construction practices

- Builders want to meet code and avoid defect litigation issues.

- Two main litigation issues: Water intrusion around windows. House doesn't cool right.
- Builder liable 10 years for defects. Insurance carriers interested in actuarial data to justify reducing premiums for builders who use improved construction methods. Potential to reduce insurance.
- Improved construction reduces callbacks and litigation costs for both builder and contractor.
- DOE Building America program claims to have reduced callbacks but offers no data.
- Problem for ComfortWise is that costs are tangible but benefits are fuzzy. Extra costs include tight ducts, Low-e glass (for low heat gain), installation protocols for insulation, diagnostics.
- There are enormous benefits. Virtually every category of insurance (from property and liability, to health and life) benefits from better construction practices. In particular, lower claims in professional liability for builders is significant.

Source of problems regarding building performance

- Water intrusion. Improper flashing associated with 1-coat stucco caused problems. The market has switched back to a 3-coat process.
- HVAC cooling. Duct leakage results in too little air or oversized system. Return air leakage affects efficiency, ability to cool.
- There isn't one conspicuous area. The building envelope, however is particularly important
- Business interruption can be triggered by poor equipment installation.
- It is important for people in the energy efficiency arena to be aware of the potential risks involved with being more energy efficient. For example, vinyl windows are heavily promoted in the energy efficiency arena but they melt and can cause fires. Tighter sealing can result in air-quality issues.

Cause of problems

- A big cause is the disconnect between the designers and the implementers. The energy efficiency community haven't given any thought to risk management. They are too focused on advocating efficiency.
- Usually energy efficiency are good, don't misunderstand. And, while there can be some problems, there is also a consumer perception that these "improvements" can go awry too and lead to fire, sick building syndrome, etc. This is not entirely true, however it's not entirely false either. You just hear more about the ones that go wrong.

Insurance premium reductions for high-quality builders

- Need data to justify reductions in premiums. There is a definite basis to lower premiums on high-quality buildings. Premiums are differentiated to support loss control, to reward low-risk customers.

Policies or initiatives to promote higher quality construction as a means of reducing insurance premiums and losses and managing risk

- Need long term warrantees on new homes.
- Documentation of benefits. Data should be actuarial quality and should document benefits from reduced litigation exposure.
- Codes arena may not be the place to try to improve overall construction quality. May be better to avoid regulatory mechanisms.
- Promote training and ethics for T24 consultants
- Promote mechanical system design. (Currently architects don't specify mechanical systems and ducts in blueprints. Contractors design on site, based on rules of thumb. Shoehorn systems into available space.)
- Promote HERS

Reduced litigation costs for builders

- There are insurance regulators. They need to be convinced that this is a good thing. There is not much quantitative data on this yet.

Linking insurance premiums with energy efficiency programs to improve construction practices

- Linking premiums to quality and efficiency would give a much stronger signal than utility rebates.
- Unlike a utility rebate, insurance credits are recurring so it would repeatedly incent.
- Safety and security and reducing chances of loss is much more important that saving energy. This could be used and positioned as a marketing strategy. Consumers don't care about energy efficiency. However, they do care about safety!
- Building codes in particular can "join forces" with the insurance community and it's really a natural link. The issues that are faced by the energy and insurance industry are not unlike those faced by this community. For example, if you have missing insulation, it is not only an energy efficiency issue, but an insurance issue as well.

Linking insurance premiums with building commissioning to improve construction practices

- Commissioning is strategic. There are a lot of different types of insurance and commissioning is a loss-control tool. It ensures that losses of various types are managed.
- What we still need are data and close claims studies. People don't really want to talk about MORE studies, however, there is really no concrete study that shows the clear linkage between claims and poor construction quality. Someone needs to go back and review all the claims and make that link. Then, once that it done, more people will see the value in linking the two.
- Get insurance companies to co-fund studies that show benefits of high-quality constrution.

Module F. Energy-efficient building and green building initiatives

Summary of Findings

Program goals and incentives to builders and developers

- Simple program application process (1 sheet, 2 sided). Sets 3 targets for increasing green building construction. Rewards each with increasing benefits. Targets reached by exceeding Title 24 and scoring energy points, as defined on the application sheet. Target 1: 20% beyond title 24 and 4 energy points. Target 2: 30% beyond title 24 and 12 energy points. Target 3 40% beyond title 24 and 30 energy points.
- Nonresidential projects can get credits for low-emission paints and solvents, water conservation measures, and construction waste management plan.
- Key benefit is quicker approval process which can save several weeks. Note that the building permit process is expedited but not the planning review process.
- Goal for city's Green Building Program is to achieve efficiencies that exceed Title 24 by 25%. The program is for multi-family housing and commercial new construction.
- Examined possibility of incenting developers to exceed Title 24 but learned that it would be far too expensive (incentives totaling at least 3% of total project costs). Wanted to avoid developing a program that simply offered a prescriptive process by which builders could just barely meet the minimum requirements.
- The Green Building Program has very few rules and is not based on Title 24. It simply states that the resulting building must achieve performance levels that are 25% above Title 24. The Program results in an Energy Performance Ordinance. Specific equipment types and/or materials are not specified (as in Title 24). The City has developed a "cookbook" of green building practices that was peer reviewed by green building experts.
- San Jose Green Building program includes all players in the construction market; architects, engineers, realtors, builders, building owners, home

owners, educators, loan agent, etc. Incentives are not yet finalized but all players are being asked how they might best benefit from a Green building program.

- Program has a review committee that reviews plans, assigns points. Program encourages preliminary review before serious design. Committee has a Title 24 consultant. Once project plans are scored, Building inspector can check that scored items actually implemented.

Problems and challenges implementing programs

- Project needs to identify more incentives to participate. Eventually improvement in marketability of buildings should add partial incentive to participate.
- Program needs to develop better-documented relationships between point assignments and measure benefits. Need lifecycle call back analysis of measures. Currently, point structure based on expert judgement.
- Any statewide program should offer flexibility to address local land use, water issues. Program would need education component for builders/developers. Need case studies by climate zone, demonstration projects, monitoring studies.
- CEC can facilitate but not mandate non-energy benefits. California needs a state ombudsman for all resource conservation who can review all kinds of technologies and construction practices for range of resource conservation benefits. (e.g., low-flow showers, toilets, composting toilets).
- Architects and builders have great flexibility with program but the implication is that they must understand energy issues and the impact of design and system changes. To help, city has developed a software program that will be made available free of charge. The software assists users in testing their projects and is also capable of suggestion changes. Software is available free of charge.
- The City will require that all proposed projects be modeled at the permitting stage so that their compliance with the Energy Performance Ordinance can be determined.

- In recognition of the difficulty of executing the program, the City plans to invest in training and educating their own building inspectors.

- **Module G. Title 24 revision process**

Summary of Findings

Opportunities to use standards to meet program objectives

- Northeast Energy Efficiency Partnerships (NEEP) notes that "the appropriate relationship between building energy codes and utility programs is for the code to require all energy efficiency measures that are now cost-effective for building owners and are common practice in the market, and for utilities to offer incentives only for those measure which exceed code, are cost-effective for society, and which need a 'market push' to lower unit costs and gain recognition and acceptance in the marketplace."
- There may be significant vested interests opposed to further increasing the level of energy efficiency required. As HMG points out, "...increasing code stringency is an arduous administrative and political process. It provides an opening for energy code opponents to attack the entire code, and so carries some risk for those who support current codes, or who would advocate more stringent codes." Furthermore, efforts to increase standards stringency may further add to standards complexity.
- Members of the public may not see or understand the public benefits standards provide. As a consequence, they may perceive energy standards as social engineering or unnecessary government intervention.
- Code simplification is critically important. Most of the jurisdictions studied are looking for simplification of the energy standards (Valley Energy Consultants 1993). The less complex the code or standard, the greater it appears that it will be used and/or enforced (Crowder and Foster 1998). It's clear from both the building and enforcement communities that the energy code needs to be simplified. This includes the code itself, compliance forms and enforcement techniques. Experience in Oregon indicates that the effectiveness of the code is improved when it is simpler to understand and apply (Heschong Mahone Group 1998).

- Both Northeast Energy Efficiency Partnerships (1998) and Heschong Mahone Group (1998) argue in favor of energy efficiency program interventions to support standards activities.
- Programs can provide data on baseline new construction standards, make technical and program staff available to aid in the upgrade process, and provide testimony or letters of support for standards upgrades.
- The County of Santa Barbara's innovative building review committee provides incentives for buildings that exceed Title 24 by 20%, 30% and 40%. EPA Energy Star homes are required to exceed Title 24 requirements by 20% to 25%. The City of San Diego's green building policy requires all municipal buildings that are built or retrofit to perform 50% above Title 24.
- The City of Irvine has developed a program which refunds energy plan check and energy inspection fees to builders who participate in their program (City of Irvine 1997).
- Title 24 standards should be run through "reality check." A lab was built in San Ramon to simulate temperatures and compared SEER 10 to SEER 12 AC units. Results was that SEER 10 can out-perform SEER 12 at higher outdoor temperatures. Standard should be based on tests at high temperatures (e.g. minimum standard-SEER 10 and EER = x @ 95 degrees)
- R&D has produced useful input to DOE standards. CEC, NRDC, Oregon State Energy Commission, ACEEE all support. However, standards still serve as the lowest common denominator.

Who are the key stakeholders?

- BIA, manufacturers (particularly of HVAC equipment), utilities (spotty participation, although Stan Cattaoka used to regularly monitor proceedings for PG&E). Utilities were involved in the 1980s debate over heat pumps v. gas furnaces. At that time, Hunt represented Carrier. Debate bogged down over modeling issues. 2 protagonists were SCE and SCG.

- Architects used to be involved, e.g., Dolan (San Ramon architect who does subdivision plans). Now architect interests primarily represented by CBIA (Consol represents them). Architects should be more involved.

How do stakeholders go about making their needs and interests known?

- To be effective, stakeholders need to help set the agenda of changes to be researched and considered. For the most part, CEC staff generally set the agenda by developing a list of proposed changes and assembling the basic information needed to evaluate the proposals. Coming into the process late is ineffective. CEC particularly want to avoid new issues being raised at the hearings and Order Instituting Rulemaking OIR proceedings.
- Debates for changes to standards often center around warring computer models. The debate between heat pumps and gas furnaces was particularly adversarial.
- Contractors are not receptive to new equipment. They select equipment on the basis of first cost, easy availability, and ease of installation.
- Manufacturers resist offering new equipment because of added costs for production, testing, marketing. The performance of the new unit must be bulletproof. Adding new units to the product line up would have no effect on their market share.
- We need a reliable computer simulation model that everyone can agree accurately calculates the impacts of the proposed changes. Currently, CEC is limping along with its public domain software and is hampered by developers' rules, which makes software upgrades difficult. In addition to basic compliance software, "research-level" software is needed that can model both existing standards and also proposed changes. Right now, the entire industry is dependent on the altruism of Dodd and Nittler to develop the modeling tools.
- PGC funding could be alternative for developing modeling software (avoid contracting hassles). Would need CEC blessing. Utilities have a statewide group on Codes and Standards, which could fund research, make software available to stakeholders, provide technical support. Users would need to be registered. Could be intellectual property concerns for

someone developing tool for public domain. Software should be modular, organized like ASHRAE Toolkit.

- To be effective, stakeholders should be prepared to present cogent arguments to support their energy budget calculations, evidence cost effective economics, indicate feasible implementation process or enforcement mechanism, and describe potential market acceptance. In addition, suggested changes should be consistent with typical construction practices (e.g., 22% allowance for leaky ducts to reflect current duct installation practices)
- Examples of success stories in influencing standards include the inclusion of tight duct credits, the changes in the window market, and the success of T-8 bulbs and electronic ballasts.
- The main role for utility DSM/MT programs has been to develop market acceptance and drive product prices down.

What would be your top priority for future changes in the standards? How might the standards be improved?

- TDV (which opens the door to load shifting measures)
- Model true performance of residential HVAC (nonresidential modeling just needs fine tuning). Avoid relying on bulk seasonal efficiency metrics such as SEER AFUE, energy factor)
- Reduce nonresidential Lighting power density
- Residential windows
- Residential insulation quality
- Shift tight ducts from ACM to mandatory measure
- Require commissioning and 3rd party inspections. (Caveat: do not bypass local jurisdictions)
- Load management gets mixed treatment from regulatory perspective. Under DSM, cost/benefits were calculated using Total Resource Cost test (TRC), which includes both energy and capacity costs/benefits. Under MT, PUC switched to Public Purpose Test (PPT), which considers only energy

cost/benefits MT emphasis reflects NRDC focus on energy efficiency for air quality purposes.

- During the last round of T-24 revisions, PG&E's T&D staff pushed for inclusion of demand issues in T-24. The cost of generating electricity varies by time of day and by season. These variations should be reflected in cost-benefit calculations that determine whether measures are cost effective for inclusion in T-24; i.e., T-24 should include Time Dependent Valuation (TVD).
- PG&E/CEC funded joint project, "Dollar-based standards." CEC wanted to revisit T-24 cost-effectiveness calculations in context of deregulated energy market and research part-load performance of HVAC.

From your experience, what steps or activities are necessary for a stakeholder to be effective in influencing the direction of revisions?

- Idea needs champion willing to push massive, time-consuming, coordinated effort. Someone must think through the entire diffusion process (identifying opportunities, R&D, demonstration and field testing, commercialization, broad-based market acceptance, standards mandate) and work out coordinated plan for affecting each stage. Entire program design process must be coordinated. Currently, the process is ad hoc. For example, PG&E has multiple programs that promote residential HVAC equipment. Different programs use different definitions of energy efficiency.
- Standards may be difficult for users to understand, may require difficult compliance procedures, or may be difficult for building departments to enforce.
- Target program activities toward emerging technologies or design techniques that are not yet standards requirements.
- Raise public awareness of standards requirements.
- Assist in trade ally training programs.
- Effective application of the standards requires an educated building design and construction community. Education is required on an on-going

basis to account for turnover within that community and changes in construction practice.

- Some building departments may view enforcement of standards requirements as an "unfunded mandate." Others may lack the qualified personnel necessary for adequate enforcement.
- Need coordination within utility and also across utilities. Planning process needs support from upper management on down.
- Regulatory environment needs to change to promote creative thinking among program managers. Under DSM, there was plenty of money and plenty of flexibility even though formal system focused on end users and measured kWh savings. Under MT, utility earnings potential from energy efficiency activities greatly reduced so any program manager activity that does not directly contributing to meeting milestones and earning revenue is discouraged.
- Scoping Study framework is essentially static. Overlooks how markets change over time, thus misses importance of coordinated program planning over the entire diffusion path.
- MT-focus calls for higher-risk initiatives. Outcome of efforts to influence markets less certain than efforts to influence individual customers. Need mechanism to shield administrators from revenue risks.
- Utilities have become more risk-averse. For example, a utility's low-income furnace program ended up costing $20–30 million due to faulty equipment. As a result, all utility programs get close legal scrutiny. Resulting paperwork requirements—such as a proposal that customers sign a four-page agreement simply to allow monitoring of their lighting fixtures—have caused programs to be scuttled.

Module H. Using Title 24 to promote energy efficiency program objectives

Summary of Findings

Role of standards in the broader energy efficiency context

- Standards serve to set a floor, a baseline from which to measure
- Standards move newer technologies forward. You have people that may not use the newer technologies, unless you require them to do so.
- One has to be care that standards don't become too inefficient for people to implement—they must be kept up to date.
- It started out as state commission in 1979, trying to promote solar energy. Since then, we try to go beyond what the standards are. We try to go beyond the code.
- Mr. Mattinson feels that without codes and standards, energy efficiency will never 'take off'. And, without the current codes and standards, he doesn't thing we'd even be where we are today (even though we have a long way to go), with respect to energy efficiency in the marketplace.
- He believes that standards have been really important in moving consumer and the building industry forward.
- He supports it, in general, especially with technologies such as windows.
- It's important to deliver accurate and unbiased information. For example, in DSM programs there was too much money spent on thinking we could change builders and make them sell energy efficiency. But when the money [rebates] stopped, they went back to their old ways.
- We need to ensure that they [builders] have a knowledge of what the benefits are.
- Does not think that the government can educate consumers. Third party needs to do this.

Ways that California energy standards address the public interest regarding energy efficiency

- It depends on the standard. Some can move technologies forward and speed adoption of newer cost effective measures, others may not.
- Must evaluate the standards to determine if they are working.
- It's good for low income households, that's for certain. Standards should apply to more retrofit home. Bring up the old housing stock to the new standards.
- The billions of dollars spent on better homes, you would never have this otherwise. Before there were codes and standards, people had energy bills as high as $300 a month. This just doesn't happen anymore, and consumers will not allow it to happen anymore.
- In today's market, with houses being so easy to sell, builders can skimp and it doesn't really effect the sale of the house. However, there are some areas that people have come to expect, for example, double-paned windows and insulation. There is a certain level of threshold that consumers are willing to put up with, but it's much lower than what it was before codes and standards.
- Education. There has not been enough of a 'pull' from consumers for energy efficiency, so they need more educational programs that help with this.
- Consumers won't ask for what they don't know.

Ways in which standards fall short of meeting the public interest

- In terms of older homes, they should be brought up to at least minimum code at the time of sale.
- Once rebates end, there will be no incentives for people to participate so don't use rebates.
- There is irregular enforcement of standards.
- The Commission itself must start to look for more ways to be proactive with market actors. It's not so good for consumers. Market actors can look

out for themselves, they have a ‘voice’ with ‘the powers that be. Consumers on the other hand do not. Market actors regularly attend Commissioning meetings where they can voice their opinions, but consumers do not.

Important of standards incorporating emerging energy-efficient technologies and practices

- People rarely use any compliance paths that are not prescriptive.
- It’s important to have different paths so people can try their own way, especially in the CA climate, where climates are so different.
- Firm believer in having alternative compliance methods, which CA has (but not all states do). There are such diverse climates in CA, you have to have flexible compliance methods. For example with window shading and other technologies, the window covers never took off, and it was important to allow builders to try alternatives.
- Seems like they can push energy efficiency levels and that would include newer technologies. There’s a problem meeting Title 24, a problem with design.

Role of energy efficiency or market transformation programs in the broader energy efficiency context

- There is a role to foster new and improved technologies.
- It must be shown to people city by city. Just because it works in L.A. doesn’t mean it will work in San Francisco.
- If it is in the interest of the state, then it’s worth it. They can find new technologies, try new programs.
- Improves air and water quality as well.

Opportunities to integrate the standards and the programs to more effectively promote common objectives

- SCG is investigating better ways to provide energy efficiency. Current focus is on educating customers, builders, contractors. "Home buyers think that all housing is energy efficient" Maybe Energy Star fixes misunderstanding.
- Energy Star is hook. It provides a common platform for coordinating utility programs.
- SCG is working with CEC, talking to Bill Pennington. Utilities are working closer together. For example, they are collaborating to develop training programs and resource guides. However, each utility has already established its own energy efficiency niche and its own style of relating to its customers. Utility programs will never become entirely uniform.
- Standards support utility programs by serving as exit strategy for programs.
- Utilities can provide support for future revisions to standards by helping CEC work around its contracting problems and augmenting CEC research activities (e.g., residential quality assurance project)
- Utilities can help day-to-day implementation of the standards by supporting local jurisdictions (e.g., inspector training re T-24, changes to standards)
- There is a real need to target the builders. We need to *show* them the benefits. They [Sol Data] did a CA window initiative with builders where they learned that builders were too busy to attend any sort of training class or workshop. So, they had to be creative. What they did was one-on-one training at the builders' job site—hands-on training. This was very well received. The utility [who paid for the study] felt it was too costly, but it was well worth it. The builders were much more open to a third party coming in, since they had nothing to gain by showing them the newer/latest technologies. Plus, they were not related or affiliated with the government.

- Programs should try to go beyond the codes and standards. Programs should require testing.
- Program connects local governments to get information about energy efficiency, marketing, green building programs, low income and energy efficiency improvements.
- Work directly with local governments to build energy efficiency improvements and neighborhood improvements (are of planning in new development areas)

- They look at solar opportunities first; then look at the streets (how wide they are); then shade trees (require trees). They look at neighborhoods and how they can make the neighborhood energy efficient rather than individual homes.
- It doesn't cost the builder any more because they have saved money on neighborhood improvements.
- The standards define the terrain, and the programs find niches to satisfy the standards.
- The standards are there to establish a baseline.

Examples where the standards and the programs work at cross-purposes

- Many programs still push adoption of specific technologies and construction practices. However, most projects comply with T-24 using performance method, based on meeting an energy budget. Energy efficiency gains from adopting utility recommendations are traded off for less energy efficiency elsewhere in the project for no net gain in building energy efficiency.
- As program-promoted measures gain acceptance in the market, they need to be incorporated into the basic list of mandated measures under T-24. Prototypical building CEC uses to represent current building practices needs to be modified to reflect measure adoption in the market. Energy

budgets developers must match for performance-based compliance must be revised to reflect changes.

- T24 treatment of emerging techs
- CA having multiple standards is very useful. It allows builders to have flexibility. They can't just install the same thing for everyone everywhere, the climate is too diverse.

Module I. Utility involvement in the Title 24 process

Summary of Findings

- Assist in standards administration and enforcement. Utilities can require certification of standards compliance as a precondition to electrical service hook-up. They can also fund technical consultant to work with developers and building inspectors to help projects meet standards requirements. Finally they can contract with government to perform standards compliance services such as plan reviews and site inspections.
- Utility advocacy of code enhancements by proposing code changes, providing analysis of the costs and benefits of proposed code changes, and providing testimony at regulatory hearings
- Utility/MT promotion of new, stricter codes after they are promulgated but before they become mandatory
- Use of MT funds to offset code adoption costs, offer code official training, offset increased inspection costs, provide technical support, and offer incentives to cover increased building costs for the transition period
- Utility/MT promotion of Reach codes on a trial basis
- Use of sliding scale hook-up requirements and fees based upon level of code compliance
- Studies have shown that utility support can improve adherence to Title 24. In one PG&E study, the Title 24 compliance margin for home built under the program was nearly twice as great as that for nonparticipants. Nonparticipant homes were more than ten times as likely to fail to comply than participant homes.

- Ongoing program incentives are not always necessary to maintain improvements in construction practices. According to that report, field experience in North Carolina and Florida shows that HVAC contractors, after completing program-sponsored duct installation training, continued installing tight duct systems without any utility incentive.
- ComfortWise (Consol's privately run, residential new construction DSM) provides builders with marketing support, access to improved financing, and HERS and diagnostics testing
- ACT2 program homes achieved 50–70% improvement in energy efficiency. However, the housing industry is not ready for new technologies due to being extremely risk averse. To be accepted, technologies must be "bullet-proof."
- PG&E has two residential new construction programs: Comfort Home and Energy Star. Comfort Home focuses on HVAC systems in new construction in the Central Valley. Under Energy Star, builders receive an incentive to build model homes or showcase homes to Energy Star standards. PG&E provides marketing support and sales staff training on issues of energy efficiency, comfort, quality and money.

E. UTILITY ACTIVITIES RELATED TO CODES AND STANDARDS

PG&E Codes and Standards Programs

This information was excerpted from the PG&E Application, September 1999, provided by Pat Eilert of PG&E. Additional information about other related programs run by PG&E is contained in Volume I of this report.

New Construction Codes & Standards Support & Local Government Initiatives

Program Summary

This integrated program seeks to support market transformation across both new construction and remodel/renovation markets to the extent that both new construction and major tenant improvements involve the same market participants and are subject to California's "Energy Efficiency Standards for Residential and Nonresidential Buildings," also known as Title 24 Energy Standards. The program addresses standards-setting organizations such as the American Society of Heating, Refrigerating and Air Conditioning Engineers; code-setting bodies such as the CEC and the USDOE; and enforcement authorities such as cities and counties.

Energy standards and codes are central to capturing the public policy benefits of energy efficiency programs. Standards provide a creditable and replicable means of performance measurement, allowing a fair basis for comparison between alternative products and practices. Codes provide enforceable minimum levels of performance. The combination of standards and codes establishes the baselines from which energy efficiency improvements can be evaluated and below which market participants may not specify efficiency levels.

Energy efficiency gains in design practices, building shells or appliances are not completely captured for society until they are routinely incorporated in standard practice or reflected in improvements to standards, codes and building energy budgets. The current Title 24 standard, which was acted upon in 1998, is scheduled for substantive revision in 2004. The hearings on the next revision are scheduled to begin in 2002. The Energy Standards program will develop and seek consensus on recommendations to be considered by the CEC prior to the start of the hearings. Future program efforts will advocate for recommended improvements during the hearings.

The Codes and Standards program is expected to transform the market by working with federal, state, and local policy-makers to develop a culture which seeks continual advancement and improvement of the standards consistent with opportunity. Collaborative proposals will be emphasized. Efficiency codes and standards occur at the local, state and national levels, so the Codes and Standards program will emphasize participation in and coordination with efforts at all these levels to ensure collaborative upgrade efforts.

<u>Codes and Standards</u>

The Codes and Standards program element proposes to bring about upgrades in standards and codes, thereby capturing the benefits for society from California's diverse energy efficiency market transformation efforts. The case for improvements will be developed for promising design practices and technologies, such as those developed in the Residential and Nonresidential New Construction programs, and will be presented to standards code setting bodies in a coordinated manner. If the improvements gain consensus support, there is a high likelihood of adoption during the next code revision cycle.

This element will carry out a range of activities supporting implementation of existing codes as well as development and adoption of upgraded codes and standards. Mechanisms to improve availability and use of code training will be developed and implemented. New, voluntary design guidelines that exceed current efficiency requirements will be developed. Participation in local, state, and national code and standards development and upgrade efforts will be supported.

Upgrading codes and standards is an ongoing opportunity, the first step of which is often the development and adoption of voluntary design guidelines that exceed current efficiency requirements. For example, "Stretch Codes" which exceed current codes might be promulgated and then adopted by developers, builders, or municipalities. This "Stretch" effort will help to bring exceptional methods into the mainstream and will eventually raise the bar of energy efficiency for all. Educational programs and training on these advanced opportunities would improve the breadth and depth of knowledge of trade professionals, building owners, and building officials. It will be important to work closely with entities such as the California Building Industry Association to achieve this goal.

A special effort started in 1998 to examine the potential implications of changing the source energy basis of the State's Energy Code will be continued. With electric industry deregulation, there is widespread interest in examining whether the basis of the energy code should be changed to a "Cost Basis" rather than the current exclusive "Source Energy Value" basis.

Market transformation can be accomplished by providing training and establishing mechanisms that would institutionalize the provision of code compliance training on a self-sustaining basis in the future. The utility's energy and training centers will play leading roles in developing and delivering this training: PG&E's Pacific Energy Center (PEC), Stockton Training Center (STC), and Food Service Technology Center (FSTC); SCE's Customer Technology Application Center, and Agricultural Technology Application Center.

Market Objectives

- Influence improvement in energy efficiency codes and standards; and
- Influence participants to view codes as a minimum which can and should be exceeded.

Targeted Market Participants and/or End-Uses

Participants:

- Standards-setting organizations such as the American Society of Heating and Refrigerating and Air Conditioning Engineers, the Illuminating Engineering Society, the Institute of Transportation Engineers, and the American Society of Tool and Manufacturing Engineers
- Code-setting bodies such as the CEC, the USDOE, and the Federal Trade Commission
- Building rating systems such as the U. S. Green Building Council's Leadership in Energy and Environmental Design Green Building Rating System

End-Uses/Improvement Opportunities:

- Code scope and administration
- Building envelope
- Mechanical
- Electrical and lighting
- Other: Performance-based Code, Cost-Based Source Energy Values, and Light Emitting Diode Exit Signs and Traffic Signals

Implementation Strategies & Activities

- Work with government officials, interest groups and public and private organizations to institutionalize higher levels of efficiency in state and federal codes and standards.
- Offer code training and design professional education to inform and promote construction which reaches for higher achievement by substantially exceeding code minimums;
- Support the development of design guidelines to encourage construction which exceeds current efficiency requirements.

Theory of Market Change and Desired Market Effects

By incorporating high-efficiency equipment, materials, and design practices into codes and standards as they become more typically used by key constituents, the practice will be institutionalized and sustainability assured.

By encouraging the early adopters and early majority to adopt voluntary competitive strategies that exceed code efficiency minimums, a stronger case can be made for the practicality of improving the standards;

By working with local governments to encourage construction that exceeds code minimums and actually performs as well as predicted, the concept of exceeding minimum levels of efficiency will be demonstrated to be financially beneficial and will be incorporated into standard practice.

Program Performance Indicators

Prepare and technically refine technical arguments for code improvement and submit to the CEC and interested parties.

Commence discussions with key stakeholders by 11/30/00. Manage and actively participate in a public consensus building process that includes the CEC, representatives of the building industry, professional organizations, environmental groups, building energy consultants, and utilities.

San Diego Gas & Electric's Programs

Brief descriptions of relevant programs. Excerpts are from SDG&E's May 1, 2000 filing.

RESIDENTIAL

Energy Efficient Mortgage (EEM) Housing Resale

Program Description

SDG&E's Energy Efficient Mortgage program promotes energy efficient mortgages to residential customers for the purchase and refinance of existing homes. The program, which is marketed to realtors and lenders, unites homebuyers with lending institutions that offer EEM's. Through the EEM process, customers can include the purchase of energy efficient upgrades in their mortgage at the time of purchase. To participate, customers must have a Home Energy Efficiency Rating (HERS) completed on their home which is used to evaluate pre-existing equipment and recommend upgraded energy efficient measures. Energy efficient improvements which may qualify under the EEM include: high efficiency central heating and cooling systems, high efficiency water heaters, wall insulation, high performance windows, and compact fluorescent lighting.

Residential Contractor Program (RCP)

The Residential Contractor Program (RCP), a statewide effort, was developed by the four California utilities with input from various agencies and public parties. The program provides incentives to customers to encourage them to work directly with contractors to achieve energy efficient upgrades. The program is targeted at the single family (SF-RCP), multifamily (MF-RCP), and mobile home market sectors. The SF-RCP is designed to provide benefits to customers with older houses that have significant energy savings potential. In order to participate in the SF-RCP element, the customer must hire a contractor from the League of California Homeowners.

The Multi-Family element is designed to foster energy efficiency improvements in apartment buildings by promoting sustaining relationships between apartment building owners/property managers and contractors/Energy Service Providers. Financial incentives are available through standard performance contracts (SPC), for retrofits performed by contractors/EESP's. The Multifamily Element supports financial incentives based on the energy savings from virtually any energy efficiency measure. In order to participate in the MF-RCP component, the dwelling must be an existing unit in an apartment building with five or more units (common areas are also eligible).

Downstream Appliance Incentives

The Downstream Appliance Incentives program is a statewide effort which promotes dishwashers, clothes washers, room air conditioners and refrigerators that qualify under the Department of Energy's criteria for energy efficiency. Under this program customers may receive rebates for purchasing certain ENERGY STAR® qualified products from participating retailers

Contractor Training Program

The Contractor Training program provides no cost training to local contractors on the importance of employing industry standard practices for the installation of HVAC systems. The program was specifically designed to increase the number of licensed contractors who regularly use Manuals "J" and "S" to determine accurate sizing of air conditioning units. Contractors who attend training are given manuals "J" and "S" for their business use. All licensed HVAC contractors in SDG&E's service territory are eligible to attend training.

Statewide Upstream Appliances

The Statewide Upstream Appliance program promotes improved distribution, stocking practices and product availability of qualifying ENERGY-STAR® rated appliance models at participating retailers. The program targets upstream retailers and manufacturers to encourage increased ENERGY-STAR® appliance shipments to local retail stores. In order to participate, retailers and manufacturers must sign an agreement with SDG&E agreeing to abide by program procedures and guidelines. By participating, retailers and manufacturers receive the following benefits:

- Eligibility for Sales Person Incentive Fund (SPIFS) and Co-op promotional incentives
- No cost training for employees
- Free ENERGY-STAR® product materials
- No cost Point of Purchase materials (POPs)
- Increased demand for ENERGY-STAR® products/increased sales
- Free advertising

Targeted Third Party Initiative

The 1999 Residential Targeted Third Party Initiative (TTPI) was designed to facilitate efforts in the statewide single family element of the Residential Contractor program. A third party contractor selected by competitive bid conducted the training in SDG&E's service territory. Although the main focus of the training was to support training efforts in the Residential Contractor Training program, the TTPI also supported training efforts in the Upstream Contractor Training program. Training classes offered under this TTPI included Basic Heating and Cooling Tune-up, Duct testing, Combustion Appliance Safety Testing (CAS), Installation of High Performance Windows, and Installation of Wall and Ceiling Insulation. A "test out" approach was used in order to provide a mechanism for experienced contractors to qualify for certification without having to take the class. Once certified, contractors are eligible to participate in the single-family element of the RCP program.

Lighting Fixture Program

SDG&E's Lighting Fixture program was a continuation of the 1998 Fixture program for the first six months of 1999, as an interim lighting program in effect until the Statewide Lighting program began in June 1999. Under the program, fixture manufacturers were eligible to receive financial incentives for increasing shipments of ENERGY STAR® lighting products to local retailers. The program utilized the Environmental Protection Agency's (EPA) ENERGY STAR® residential fixture technical specifications as the criteria for manufacturer participation. Manufacturers who expressed interest in participating were required to sign an agreement with the EPA to produce energy efficient products. By partnering with the EPA, manufacturers were able to package their products with the ENERGY STAR® logo.

Distributor Program

The Upstream Residential Distributor program provides local distributors with financial incentives for stocking and promoting high efficiency (12 SEER and above) split-system HVAC units. In order to participate local distributors are required to sign a contract with SDG&E agreeing to program guidelines and requirements. Distributors are required to provide documentation to verify the number of high efficiency (12 SEER and above) units, which are stocked at any given time for sale in SDG&E service territory.

ENERGY STAR® Windows

The ENERGY STAR® Windows program, designed to target window manufactures, component suppliers, and retailers, was implemented in 1999 through a third party. This program provides upstream financial incentives to window manufacturers for stocking and supplying ENERGY STAR® Windows at the retail level. A second component is downstream support, which includes training for sales associates at home improvement stores, and consumer training, interactive point-of-purchase materials, advertising support, and reporting and tracking of sales for participating retailers.

Statewide Upstream Lighting

The Statewide Upstream Lighting program, which replaced SDG&E's Lighting Fixture program in June 1999 is a cooperative effort of the four utilities. SDG&E worked closely with the utilities to develop the statewide program, which promotes ENERGY STAR® lighting to manufacturers and retailers. The Statewide Lighting program is aimed at the residential upstream market (manufacturers) and the midstream market (retailers, vendors) for energy efficiency. In order to participate, manufacturers and retailers must sign an agreement with SDG&E. As with the Statewide Appliance program, benefits to manufacturers and retailers include: No cost training for employees, free ENERGY-STAR® products/ materials, no cost Point of Purchase materials (POPs), increased demand for ENERGY STAR® products/increased sales and free advertising.

NONRESIDENTIAL

Information

The Nonresidential Information program provides information about energy efficiency and services and introduces customers to state-of the art efficient technologies and practices through workshops and seminars. Facility managers of large businesses (greater then 500 kW demand and/or 250, 000 therms) are notified of the workshops and seminars through mailed invitations. Business owners and property managers of small/ medium businesses (less than 500 kW and/or 250,000 therms) are notified through direct mail invitations and through business and trade associations.

Statewide Energy Guide

The Statewide Energy Guide " Smarter Business Energy Use, Saving Energy & Money" is an energy information and education guide designed by the California utilities to give customers information that will empower them to better manage their business energy costs. Development of the guide represents specific energy efficiency information to both customers and other market actors, such as energy efficiency service providers and contractors. Customers can call SDG&E's Customer Service to request the Statewide Energy Guide or they can access the electronic version of the energy guide on SDG&E's website.

Energy Efficiency Financing (Energy Cents)

The Energy Cents program is a cooperative effort between SDG&E and SAFE-BIDCO, a non-profit state organization offering low-cost financing to customers interested in installing energy efficient projects. Through this project, there is no initial cash outlay by the customer. SAFE-BIDCO agreed to waive their usual application-processing fee for SDG&E's customers with a qualifying small/medium commercial audit. This financing can be used by customers, in addition to other SDG&E incentives, to facilitate installation of energy efficiency projects. SAFE BIDCO defines a small business customer as one with a net worth less than $6 million with average net annual income less than $2 million. For eligibility requirements and an application customers can contact SDG&E, or may call SAFE-BIDCO directly.

Building Operator Certification

The Building Operator Certification program aims to promote energy efficient operations and maintenance practices in nonresidential buildings by establishing a training and certification program for building operators. The program establishes a standard of professional competence in energy efficiency by focusing on practice oriented education where skill development is more likely to be attained. Upon successful completion and approval of all qualifying segments, participants receive a certificate. The certification program is comprised of five courses, which are conducted by the University of California San Diego (UCSD). To encourage individuals to participate in the program, SDG&E funds half of the certification tuition. To enroll, customers must register through the Extended Studies Department at UCSD.

Third Party Initiative - Small Cities Energy Efficiency Retrofit Demonstration Program

SDREO, through the San Diego State University (SDSU) Foundation, will direct comprehensive audits for the facilities within three small cities. SDREO will evaluate city procurement practices, facilitate the adoption of energy efficiency retrofits as identified in the audits above, determine the benefits of retrofitting LED traffic signals in two of the cities, and identify emerging technology potential within the HVAC system at the City Hall of one city.

Tenant Improvement Program

This program is implemented through the nonresidential new construction Savings By Design and Energy Design Resources programs. It is designed to encourage and assist building owners, developers, or occupants of tenant improvement projects to incorporate energy efficiency technologies into the building design. It also provides financial resources, information and incentives. Refer to Nonresidential New Construction for program details.

Emerging Technologies

New energy efficient technologies are not often implemented by customers and energy efficiency service providers (EESPs) because of low awareness of the availability of emerging technologies, uncertainty of the benefits of the technologies or prohibitive cost. In 2000, SDG&E will work with large customers to develop demonstration projects that will showcase emerging technologies.

In addition, SDG&E will also work with the Emerging Technologies Coordinating Council (ETCC), a new organization currently comprised of members from SDG&E, Southern California Edison (S), Pacific Gas &Electric (PG&E), Southern California Gas (SoCalGas), and the California Energy Commission (CEC), to identify emerging technologies.

Express Efficiency

Through the Express Efficiency statewide program, an alliance of Trade Allies (contractors and distributors) helps market the benefits of energy efficiency. Financial incentives for lighting, air conditioning, refrigeration, food service, and gas equipment are offered to small commercial customers (less than 250 kW and 250,000 therms) through a direct rebate process. The contractors and distributors provide rebate incentives to customers on qualifying equipment at the point of sale. For each qualifying piece of equipment purchased, SDG&E reimburses contractors for the amount of the incentive they provided to the customer. In order to encourage the contractors to promote energy efficiency measures, midstream incentives are provided to participating contractors. Measures, technical requirements, and most rebate levels are consistent statewide and are published in statewide program materials.

The Express Efficiency program will be implemented through participating distributors, contractors, and EESPs. The California utilities will work together to develop program materials in a cooperative effort and will continue to refine the program as needed. Workshops will be held to educate small/medium customers on energy efficiency measures and the benefits of installing energy-efficient equipment.

Commercial Dishwasher Pilot Program

The Commercial Dishwasher Pilot program for 2000 will assess the effectiveness, including the costs and benefits, of emerging dishwashing technologies. The potential target market includes an estimated 4,800 restaurants, hotels, medical facilities, schools, colleges and universities. SDG&E plans to work with a limited number of customers to demonstrate these technologies.

Third Party Initiative - Horizontal Washers Program

This program targets the commercial market to promote the purchase of energy efficient horizontal clothes washers for laundromats and common-use laundry rooms in apartments, dormitories and barracks. SDG&E contracted with the San Diego County Water Authority (SDCWA), through the 1998 third party program, to augment their Commercial Industrial, Institutional (CII) Voucher Incentive Program (VIP) toward the purchase of coin-operated washers by providing a larger incentive than the current voucher offered by the SDCWA.

Large Nonresidential Standard Performance Contract

The Large Nonresidential Standard Performance Contract program (LNSPC) is a performance-based statewide retrofit program that offers incentive payments for projects delivering verified energy savings at large commercial, industrial and agricultural customers facilities. The fixed price, performance measurement protocols, payment terms, and all other operating rules of the program are specified in the program procedures manual. The program was developed with guidance from the CBEE and its Technical Advisory Committee.

FasTrac Performance Contracting Pilot Program

The FasTrac Pilot is a pilot program for 2000, formulated to test the feasibility of using performance contracting for large customers with smaller energy efficiency retrofit projects not suited for the Large Standard Performance Contract (LNSPC) program. The FasTrac pilot will preserve many of the essential features of the LNSPC program while providing a more streamlined and simplified application, measurement and verification (M & V), and funds disbursement process. Large customers (equal to or greater than 500 kW) and chain accounts (two or more SDG&E accounts), with energy efficient lighting or HVAC projects, are eligible to participate in this project. Project Applications must be submitted through a third party project sponsor, (such as an energy efficiency service provider, a lighting contractor, an HVAC contractor, etc).

Small Business Standard Performance Contract (SBSPC)

The Small Business Standard Performance Contract (SBSPC) program is a performance-based, statewide retrofit program that offers incentive payments for energy efficient projects that deliver verified energy savings at small/medium sized customer facilities (less than 500 kW demand or 250,000 annual therms of usage). This program offers fixed incentives for documented energy savings achieved by installing specific energy-efficient measures. The fixed price, performance measurement protocols, payment terms, and all other operating rules of the program are specified in the program procedure manual. The Project Application must be submitted through a third party project sponsor, (such as an energy efficiency service provider, a lighting contractor, an HVAC contractor, etc).

Upstream HVAC Incentives

SDG&E will offer standard upstream incentives to manufacturing distributors to encourage the promotion of premium efficient package A/C units instead of units with standard efficiencies. The Nonresidential Upstream HVAC Distributor Incentive program is designed to improve the current stocking practices of local HVAC distributors by increasing the inventory stock of split and package system air conditioning units to the Consortium for Energy Efficiency (CEE) Tier 1 energy efficiency level. This strategy is expected to achieve its goals by providing a financial incentive to distributors for stocking CEE Tier 1 high-efficiency HVAC (HEHVAC) units.

Upstream Motors Incentive

The Upstream Motor Dealer Incentive program is designed to improve the current stocking practices of local motors dealers by increasing the inventory stock of premium efficiency motors that meet the Consortium for Energy Efficiency (CEE) rating for premium-efficient motors. It addresses high efficiency motors, pumps, fans, and selected equipment. SDG&E provides financial incentives to dealers for stocking premium efficient motors.

RESIDENTIAL NEW CONSTRUCTION

Design Assistance

The Design Assistance program incorporates many different activities, some of which overlap other areas under residential new construction. These activities are described below.

Design

SDG&E provides design assistance services, training and marketing support to architects, sales agents, and consumers. Working through a number of energy efficiency consultants, SDG&E promotes the adoption of energy efficiency at the design level. This intervention strategy incorporates statewide training, design assistance and information efforts to ensure a consistent message is delivered through multiple channels.

SDG&E provides training seminars to builders and architects on topics such as HVAC sizing and installation, duct installation techniques, lighting, windows, selling energy efficiency upgrades, and Title 24 issues. The training is coordinated with the Building Industry Association (BIA) and the American Institute of Architects (AIA) to increase participation.

Promotion

This program offers promotional support which includes an advertising campaign featuring builders committed to energy efficiency and quality construction. In addition, SDG&E provides advertising collateral to builders, designers and contractors to help promote purchase decisions on energy efficiency.

Statewide Sales Agent Training

The statewide Sales Agent Training program provides information about energy use and energy efficiency to the people directly interacting with new homebuyers.

Statewide Builder Resource Guide

The Builder Resource Guide is used to provide builders with up-to-date information on new building technologies and practices, statewide information, energy efficient appliance and lighting technical advice, Title 24 compliance tips, and general design guidelines. The Guide reaches a broad audience, including homeowners building new homes, custom homebuilders, lower income housing developers, and production builders.

Statewide Training

The statewide training program is a coordinated effort to provide technical assistance to builders and HVAC subcontractors on new technologies and building practices. These efforts offer enhanced HVAC duct training and high performance window training on a statewide basis. This is an important step in providing a consistent message to the building industry. Furthermore, as emerging technologies are identified, the utilities look for additional opportunities to develop statewide training classes. Targeted measures include integrated energy efficient design, air conditioners, heat pumps, furnaces, boilers, water heaters, integrated systems, ventilation equipment, efficient lighting and appliances, and solar heating and cooling.

ComfortWise

"ComfortWise," a program implemented by ConSol, targets new construction for single family homes. ComfortWise covers all aspects of home construction with an emphasis on quality control. The program provides a variety of services, including engineered HVAC system layout, design and sizing, third-party inspections and diagnostics ranging from framing techniques and insulation installation to home energy ratings, ENERGY STAR® marketing support, and promotion of Energy Efficient Mortgages.

This program offers financial incentives to market participants for each home that incorporates the ComfortWise standards. Integrated energy efficient design, air conditioners, water heaters, integrated systems, and efficient lighting and appliances are targeted.

Manufactured Housing

The Manufactured Housing program will be outsourced to a third party in 2000. This pilot program will be focused on upstream market transformation by directing the efforts of incorporating high energy efficiency options in manufactured housing toward the producers of that housing. Most of the manufacturers are located in Northern California; however, even though there are no manufacturers in SDG&E's service territory, manufactured homes are located in San Diego.

Manufactured homes can qualify for this program either by having incorporated a pre-qualified package of efficiency measures into the home or by installing a custom package of measures selected by the manufacturer that will meet the program's efficiency requirements. These requirements are designed to reduce the total energy used for space heating, space cooling, and water heating by approximately 30% compared with a standard home that only meets code.

The benefit to the manufacturers in participating in this program is the increased marketability of the qualifying homes through promotion by the program of their housing. This will be done through co-op advertising for dealers, promotional materials for dealers highlighting the benefits of energy efficient homes, press releases at the manufacturer's plant and other promotional events.

California Home Energy Rating System (CHEERS)

The California Home Energy Rating System (CHEERS) is a very important element in the quality assurance of new buildings. A CHEERS certification also provides additional value to customers at the time of resale as proof that the home has added energy efficiency features. Targeted measures include integrated energy efficient design, air conditioners, heat pumps, furnaces, boilers, water heaters, integrated systems, ventilation equipment, efficient lighting and appliances, solar heating and cooling, and rooftop PV’s.

CEC’s Public Interest Energy Research (PIER)

SDG&E will continue to work with PIER through SDREO. Several of the technologies assessed during 1999 will be demonstrated in local building projects. These demonstration projects will be implemented and case studies will be developed that describe the benefits of utilizing the new technologies. Appropriate hardware technologies identified for demonstrations in the residential new construction program are: Alternative to Compressor Cooling (CIEE & Davis Energy Group projects), Dual Source Heat Pump, Integrated New Home Design, Improved Efficiency Air Conditioning Compressors, High R (>4) Windows, Indirect-Direct Evaporative Coolers, and Evaporative Condenser Air Conditioning. Design tools appropriate for program introduction as emerging technologies are the Building Design Advisor, Tool for Comprehensive Analysis of Low-Rise Residential Buildings, and Instrumented Home Energy Rating & Commissioning.

Targeted Third Party Initiatives: Designed for Comfort

Designed for Comfort is a targeted third party initiative which addresses multi-family housing needs, single family attached housing, military housing, and some custom homes. This is primarily a market transformation program that targets specific market barriers to bring about a change in the way multi-family homes are built so that energy efficiency becomes a design intent, thus making it easier to incorporate energy efficiency options into the building process. Minimal incentives are paid to the developer and design team for incorporating energy efficiency into the homes.

NEW CONSTRUCTION - NONRESIDENTIAL

Savings By Design

Savings By Design is a statewide nonresidential new construction program that is closely coordinated with the other California utilities. This program is dedicated to achieving greater savings than those required under California's 1998 Energy Efficiency Standards for Nonresidential Buildings (Title 24) that became effective on July 1, 1999. Design assistance, access to tools and training, and financial incentives are offered to promote the design and installation of high efficiency building systems that perform better than Title 24 by a minimum specified amount.

The Savings By Design program targets the primary decision-makers involved with new construction projects, including architects, engineers, contractors, builders, developers, energy consultants, and building owners. Together they address all of the following: equipment efficiencies for lighting, heating, ventilation and air-conditioning; performance characteristics for glazing and other envelope components; and inclusion of energy efficient equipment such as controls, sensors, and drives. This program offers project-specific information and assistance to these decision-makers throughout the construction process.

Design Team Incentives is a strategy within Savings By Design involving energy simulation modeling and the whole building approach. This element includes a process by which design teams can document their efforts to integrate high energy efficiency systems, simulate and evaluate their energy efficient designs, identify successful installations, and be paid for their efforts and achievements. Maximized comprehensive savings will be the outcome of this "dollars to designers" approach that relies on whole building simulation. Architects and engineers who spend additional design time on projects will be paid in relation to the energy saving options modeled and actual measures that are installed in the completed project. Utilizing the whole building approach, greater savings can be achieved by integrating the design of the building's energy systems.

The Savings By Design program also assists owners of new construction projects with financial information and incentives. The choice to include highly efficient equipment is facilitated by offering financial information regarding return-on-investment, simple-payback, and long-term savings associated with high efficiency equipment. Financial incentives, to help offset the increased first costs, are made available to owners/end-users that choose to implement energy efficiency measures. All building sizes are eligible to participate in the Savings By Design program. All new construction end uses and technologies are eligible.

Nonresidential Design Assistance

Beginning in 2000, the Nonresidential Design Assistance program will be incorporated into a statewide program entitled, "**Energy Design Resources**". This new statewide program provides benefits for all market actors by making the resources developed available through a variety of media, including a website where existing tools and enhanced resources are made available for free downloading. Quarterly industry newsletters are published, targeting key decision-makers in six strategic segments of the new construction industry that highlight and promote the advantages of energy efficient facilities. Also offered are on-going seminars and educational opportunities aimed at design professionals desiring to upgrade their energy efficiency knowledge and skills.

This information-based program is designed to work in concert with the Savings By Design program that provides incentives directly to designers who undertake an integrated energy design process to increase the energy efficiency of the buildings they design. Many of the tools and training that designers need to optimize their participation in Savings By Design are offered through Energy Design Resources.

SDG&E and the other utilities will coordinate activities in this program to further enhance the tools, case studies, and training made available through Energy Design Resources. Consistent training, applicable tools, distribution of design briefs and informational newsletters will be expanded and offered throughout the participating utilities' service territories.

Codes and Standards Support, Local Government Initiatives

This program involves working with state and local governments to facilitate, educate, train and support people who implement and develop energy codes, standards and initiatives. It utilizes local government agencies and the San Diego Regional Energy Office ("SDREO") for promotion and implementation. SDREO promotes the new construction programs under the title, "Community Energy Efficiency Programs". All residential and nonresidential new construction end uses and technologies are eligible.

The Codes and Standards element of this program involves a range of activities supporting implementation of existing codes.

The Local Government Initiatives program element recognizes the importance of city and county enforcement authorities and their ability to guide standards change and introduce energy initiatives into their General Plans.

Southern California Gas's Services and Programs

These program descriptions were provided by Lance DeLaura of SCG.

RESIDENTIAL

Y2000 Residential Contractor Program

A program, jointly sponsored by The Gas Company and Edison, is being implemented by participating contractors referred by the League of California Homeowners. Primarily through their own efforts, contractors are marketing and promoting various customer discounts on 17 different energy efficient measures for residential homeowners. Significant contractor training is conducted with emphasis on duct testing and duct sealing, proper HVAC system sizing and proper refrigerant charging.

CHEERS (California Home Energy Efficiency Rating System

A program designed to provide consumers with: an onsite assessment conducted by a trained rater, a comprehensive assessment of the energy efficiency of their home, a list of actions they can take to make their home more energy efficient, and the approximate savings associated with the measures. CHEERS rated homes that meet certain requirements are entitled to apply for an Energy Efficient Mortgage (EEM). EEMs offer more flexible loan qualifying guidelines which allow consumers to borrow more money with the same amount of income.

Energy Advantage Home

A consumer and builder service and information program that educates, encourages, and promotes the installation of energy efficient equipment and measures. This includes information about high efficient equipment, energy efficient mortgages, T-24 requirements.

Energy Star Rebate Program

A statewide program jointly administered in our area by The Gas Company and Edison that provides rebates on Energy Star rated appliances. Gas Company customers are eligible for rebates on Energy Star clothes washers of $75.

Gas Air-Conditioning Promotion

The Gas Company is advertising the benefits of natural gas air conditioning through the newspaper, on radio and through direct mail. This campaign is designed to increase the awareness of the benefits natural gas air-conditioning among heating, ventilating, and air-conditioning contractors and our customers.

THIRD PARTY PROGRAMS

Upstream High-Efficiency Gas Water Heater Program

Winning bidder has a sales target of 33,000 high efficiency water heaters .62EF in PY2000. This represents a normalized increase in sales of 54 percent compared to PY1999. The bidder provides and upstream incentive to manufacturers and wholesales to equalize the incremental cost to stocking higher efficiency water heaters.

Time-of-Sale Home Inspection Energy Awareness Program

Program goals are to:

- Integrate energy efficiency (EE) inspection services with conventional home inspections.
- Create a market-based certification program for energy efficiency home inspectors.
- Implement and energy efficient Branding Program with potential for national acceptance.

Winning bidder has a target of delivering 5,750 energy efficiency (EE) home inspections by 7/24/00 bidder proposal provides market research, a good market transformation plan, and some evidence regarding how the market is changing as a result of their market intervention strategy.

LOCAL GOVERNMENT AND COMMUNITY ENERGY EFFICIENCY PROGRAMS

The Local Government Commission

Provides leveraged energy savings by working with local government planning departments, developers, and builders early in the development process to assist them in identifying community-level and building-level alternatives for improving energy efficiency that can be incorporated into future residential and commercial development projects. During 1999 the LGC LEAP has successfully implemented projects involving 2,971 dwelling units in the cities of Huntington Beach, Lake Elsinore, Reedley, and Temecula. Energy savings range from 15 to 30 percent. This results in monetary savings in the development process that pay for the incremental cost of the energy efficiency improvements beyond Title 24. The LGC proposal provides an excellent market transformation plan and strong evidence regarding how the market is changing as a result of their market intervention strategy.

The Nonprofit Building Industry Institute (BII)

BII makes use of subcontractors in its proposal including the Colorado Energy Group, ConSol, and the California Energy Commission (CEC). The BII proposal builds upon the Community Energy Efficiency Program (CEEP) implemented in PY1999. The goal is to improve both energy efficiency and construction quality in new homes with HVAC systems that are 25% to 30% more efficient than Title

24 (30% more efficient than the Model Energy Code – qualifying them for Energy Star status). CEEP offers a clearly defined energy-efficiency program for residential new construction that can be tailored by local governments to meet their own local mandates. CEEP has been adopted by five local jurisdictions in Southern California: The City of Santa Clarita, The County of Riverside, The City of Chula Vista, The City of Carlsbad, and the County of San Diego. BII plans to continue working with 2 jurisdictions who have adopted CEEP, continue working with 2 local governments who have shown interest in CEEP, and convince 5 new cities to adopt CEEP in PY2000 beyond the 2 from PY1999. The BII proposal provides a plausible market transformation plan and some evidence regarding how the market is changing as a result of their market intervention strategy.

CTG Energetics, Inc. (CTG)

CTG includes in its program the use of GLS Research, and Sheltair Scientific, Ltd. The CTG proposal builds upon the Green Building Development Guidelines (GBDG) developed in PY1999 with the City of Santa Monica. These guidelines mandate that new construction and major renovation within the City of Santa Monica exceed the 1998 Title-24 requirements by 20 to 30 percent. The guidelines have already been approved by the Santa Monica City Council, and four new city ordinances will be adopted in July 2000 that make the guidelines mandatory for commercial and high-rise residential new construction and major remodel projects. Work performed by CTG over the past year (funded by SCG Third Party Energy Efficiency Programs) was instrumental in securing this approval. The approach consists of three key components:

- Facilitate developer/architect/engineer transition to meeting new guidelines.
- Add depth and dimension to existing green building information available to developers/architects/engineers.
- Extend existing guidelines to apply to all residential new construction.
- Identify and distribute green building development guidelines to at least 10 other cities.

CHEERS/City of Irvine

This program focuses on improving energy efficiency for new residential homes in Orange County. The primary subcontractors included in the proposal is the City of Irvine, California; an award-winning model of community integrated energy efficiency programs. The secondary subcontractors include National Comfort Institute, a national provider of air-balancing training and equipment, and Action Now, a Costa Mesa, California firm specializing in residential diagnostics and training, as well as Market Power, marketing firm experienced in energy projects.

The CHEERS program includes three components to transform the market: 1) training; 2) testing; and 3) marketing. The contractor training curriculum focuses on air balancing (proper airflow to improve efficiency), duct testing and sealing, and proper insulation installation. Available training materials will be used to train the following market actors: HVAC contractors, contractors of complimentary trades (e.g., insulation, framing, etc.), project superintendents, builder salespeople, and local code enforcement staff within Orange County. To test the performance methods used in the training CHEERS has set a goal of performing diagnostic procedures on 150 houses in the Orange County area, and provide detailed analysis of the tested homes. To further the efforts of the proposal goals the CHEERS team will develop marketing materials to be delivered to builder sales representatives and potential homebuyers. The CHEERS proposal provides a reasonable market transformation plan involving multiple market intervention strategies and market actors. Some evidence is provided regarding how the market will change in a sustainable way as a result of their market intervention strategy.

H&L Energy Savers

This program aims to develop a strategic marketing plan to introduce the "Performance 4®" simplified energy efficiency (EE) label for existing homes. The Performance 4 label demonstrates the following four benefits: 1) cleaner, 2) quieter, 3) comfortable, and 4) efficient. The program will work with home appraisers to consider increased appraised value to Performance 4 labeled homes. The target areas for launching this program are the following counties: San Bernardino, Riverside, and portions of Los Angeles. The Performance 4 program will be integrated with the following programs: Gas Company financing, Energy Efficient Mortgages, Residential Contractor Program, and Home Energy Rating Systems (HERS). A third party, the League of California Homeowners, a non-profit consumer advocate organization, would issue all certifications. The Performance 4 label is not based on a scoring system, and does not indicate a savings figure for a home. Rather, it simply certifies that a home is energy efficient. Proposed requirements of a Performance 4 certified home are as follows:

- Attic must be insulated to an R-30 standard or higher
- Walls insulated to an R-11 or greater
- Heating and cooling ducts must be properly sealed (diagnostic testing before and after to achieve target reduction level.)
- High efficiency 0.60 EF gas water heater.

Energy Technology Laboratories (ETL) LivingWise® program

This is a "school-to-home" program to educate homeowners, gather household audit information, install energy efficiency (EE) measures, and deliver information and incentives for further energy efficient home retrofits. Interested customers will be linked with RCP-Approved Contractors, or will receive more information via Internet or mail. The ETL program provides kits with 17 classroom learning activities, EE educational information, water saving showerheads, LED night-lights, and filter tone alarms. The program goal is to hand out 5000 kits to 6th grade school children coordinated with Earth Day in April and National Energy Awareness Month in October. The program is largely funded by water utilities. In their clarification response, ETL indicated that they would collect all replaced showerheads for random flow testing. ETL provided a good market transformation plan and some evidence regarding how the market for EE services might change as a result of their market intervention strategy. This preliminary market transformation assessment is based on an innovative strategy to market other EE program measures/incentives (e.g., RCP, Energy Star®, TPI) through the household audit kit including mail-in response cards and a toll-free telephone number.

Richard Heath Associates (RHA)

This program aims to train lenders and realtors on Energy Efficiency Mortgages (EEMs). The program is designed to stimulate greater demand for EEMs within the service territory of the Southern California Gas Company (SoCalGas). RHA will effectively promote Energy Efficiency Mortgages (EEM's) by training lenders, realtors, and other significant real estate market actors. RHA will produce comprehensive training material over EEM's, their use, and effective ways in marketing them. The training will also cover other products and services available in the general energy-efficiency market.

RHA will emphasize potential business opportunities available to lenders and realtors through the EEM market. The cost benefits to the consumer will also be emphasized, since these market actors will be instrumental in promoting energy-efficiency products and services to the consumer. This will also allow the lender and realtor to offer their clients with better customer service and opportunities for cost savings. RHA provided a moderate market transformation plan and limited evidence regarding how the market might change as a result of their market intervention strategy.

2000 RESIDENTIAL NEW CONSTRUCTION STATEWIDE TRAINING CLASSES

DATE	TIME	*TYPE OF TRAINING*	Targeted Audience	ADDRESS	Trainer	Contact
Mar 7	11:00 a.m. - 1:00 p.m.	**Builder Training Seminar**		Rancho Bernardo Inn 17550 Rancho Bernard Oaks Dr. San Diego	ConSol	ConSol Joni (209) 474-8446
Mar 8	11:00 a.m. - 1:00 p.m.	**Builder Training Seminar**		SCE Irvine Conference Center 23 Parker St. Irvine	ConSol	ConSol Joni (209) 474-8446
Mar 30	9:00 a.m. - 5:00 p.m.	**Title 24 Air Balance** This class will focus on the "airside" of HVAC systems. Participants will learn the technical skills required to diagnose HVAC system airside problems. The class includes product and equipment displays as well as a display house to help understand common air balance problems. Topics will include the fan laws, how to measure and adjust airflow, how to use a flow hood to balance residential systems, and corrective actions after problems are identified.		ERC/Downey 9240 E. Firestone Blvd. Downey		SoCalGas (800) 427-6584
April						
April 4	9:00 a.m. - 5:00 p.m.	**Title 24 - Manual "J"** This class provides a detailed explanation of how to perform ACCA Manual J residential heating and cooling load calculations. Several example Manual J calculations will be completed to help class participants understand the process. The class also includes equipment selection based on the load calculations and manufacturers detailed		ERC/Downey 9240 E. Firestone Blvd. Downey		SoCalGas (800) 427-6584

		equipment specifications. A demonstration of how to use the Wrightsoft brand computer software program to perform Manual J calculations is included in the class.				
April 5	9:00 a.m. - 4:00 p.m.	**Title 24 - Manual "D"** This class uses a step-by-step explanation of how to use ACCA Manual "D" to design residential duct systems. The class will explain how to use total effective length, friction rate, and available static pressure to calculate appropriate duct sizes. Other topics include air distribution within rooms, register placement, air velocity, common design problems and using Manual D in Title-24 calculations. A demonstration of how to use the Wrightsoft brand computer software to perform Manual D calculations is included in the class.		ERC/Downey 9240 E. Firestone Blvd. Downey		SoCalGas (800) 427-6584
April 6	9:00 a.m. - 12:00 p.m.	**Title 24 Introduction and Overview** This half-day class is a combination presentation on the new compliance options in the California Residential Energy Standards and a hands-on workshop on duct pressurization testing. The class includes demonstrations and displays of energy efficient windows, radiant barrier, duct testing equipment and UL 181 duct sealing products. Participants in this class will learn how the compliance options that are available with the 1998 Residential Energy Standards can be used to their advantage in new residential construction projects.		ERC/Downey 9240 E. Firestone Blvd. Downey		SoCalGas (800) 427-6584
April 10	9:00 a.m. - 5:00 p.m.	**T- 24 Duct Design** This one-day program will bring attendees the specialized knowledge they need to be able to perform the duct design required for compliance credit. This course includes review of the "ACCA Residential Design System;"		Energy Training Center 1129 Enterprise St. Stockton	Russ King, ConSol	PG&E ETC Karen Lynch (209) 932-2500

		"Manual D" duct design procedures; optimized design that delivers competitive first cost and comfort; documentation and specification of the duct design; and review of the ACCA-approved software.				
April 12	1:00 p.m. - 4:00 p.m.	**Introduction to Design Aspects of Comfort and Efficiency** This program will introduce the goals of the ***Designed for Comfort*** program and how it works with designers, energy consultants, developers, and builders. The session will cover how comfort is perceived in a residential environment and how to incorporate other qualities, such as efficiency, as comfort is addressed. We will present building efficiency measures and how their performance is modeled and quantified.		Handlery Hotel 950 Hotel Circle North San Diego	Nehemiah Stone, HMG Deb Allen, D&R International Ken Nittler, Enercomp	SDG&E Debbie Newell (619) 641-7111
April 14	9:00 a.m. - 5:00 p.m.	**T-24 Equipment Sizing & Selecting** This one-day program will bring attendees the specialized knowledge they need to be able to size and select the correct equipment. This course includes: review of the ACCA load calculation and equipment selection process; room by room loads that lead into Manual D Duct Design (compliance credit component); sizing and built in safeguards to "right size" while avoiding undersizing; and review of the ACCA approved software.		Energy Training Center 1129 Enterprise St. Stockton	Doug Beaman, Douglas Beaman Associates	PG&E ETC Karen Lynch (209) 932-2500
April 19	8:00 a.m. – 12:00 p.m.	**Builder Energy Code Training** This session will cover the specifics of building to the energy code, compliance and quality issues, equipment specifications and quality management.	Production Builders	Irvine Conference Center 23 Parker St. Irvine, CA	ConSol	SCE ConSol Joni (209) 474-8446
April 20	9:00 a.m. - 5:00 p.m.	**T-24 Equipment Sizing & Selecting** (see April 14 for description)		Energy Training Center 1129 Enterprise St. Stockton	Doug Beaman, Douglas Beaman Associates	PG&E ETC Karen Lynch (209) 932-2500

April 20	1:00 p.m. - 5:00 p.m.	**T-24 Installation Standards** This half-day course for installers or air-tight ducts will cover the Duct Installation Standards developed by PG&E and revised to be current with the most recent version of the UMC and Title 24. This course includes a full explanation of the UL181 Standard requirements; approved materials; installation criteria; sealing and testing requirements; duct insulation; and binder with resource materials.		Energy Training Center 1129 Enterprise St. Stockton	Gary Fagilde	PG&E ETC Karen Lynch (209) 932-2500
April 21	8:30 a.m. - 4:30 p.m.	**HVAC Training** A discussion of how duct design can be improved in residential buildings. Also energy efficient HVAC design practices are explored.		SDG&E 8306 Century Park Court Building 4, Room 4120F San Diego	Russ King, ConSol	SDG&E Joni Olarte (209) 474-8446
April 21	9:00 a.m. - 12:00 p.m.	**T-24 Comprehensive Code Update for Code Officials** This half-day class will review the California Residential Energy Standards for building department plan checkers, combination inspectors and field inspectors. The class will emphasize the most critical plan check and inspection items, including a list of the items that have the greatest impact on the energy efficiency of new homes. The class will include a review of the new compliance options including a hands-on demonstration of duct testing. The rules for HERS, third party, verification and inspection will be explained.		Energy Training Center 1129 Enterprise St. Stockton	Doug Beaman, Douglas Beaman Associates	PG&E ETC Karen Lynch (209) 932-2500
April 21	9:00 a.m. - 5:00 p.m.	**T-24 Air Distribution Diagnostic Testing** This one-day program will help HVAC contractors gain the knowledge and skills they need to perform the installation certification of an air right duct system. This course includes: California Energy Commission required testing and documentation; duct tester equipment operation; digital manometer operation; diagnostic testing demonstrated with on-site		Energy Training Center 1129 Enterprise St. Stockton	Gary Fagilde	PG&E ETC Karen Lynch (209) 932-2500

		training house; and blower door equipment operations.				
April 25	8:00 a.m. – 12:00 p.m.	**Building Official Energy Code Training** An emphasis is placed on the builder's responsibility and liability as part of compliance along with the need for quality control and a system of check and balances. Topics to be covered include Building Energy Code Specifics, compliance and quality issues, equipment specifications and quality management.	Building Officials	SDG&E 8335 Century Park Court Building 4, Room 1470 San Diego	ConSol	SDG&E Debbie Newell (619) 641-7111
April 25	9:00 a.m. - 4:00 p.m.	**Title 24 - Manual "J"** (see April 4 for description)		9400 Oakdale Ave. Chatsworth		SoCalGas (800) 427-6584
April 27	9:00 a.m. - 4:00 p.m.	**Title 24 - Manual "D"** (see April 5 for description)		9400 Oakdale Ave. Chatsworth		SoCalGas (800) 427-6584
April 28	9:00 a.m. - 12:00 p.m.	**Title 24 - Introduction and Overview** (see April 6 for description)		9400 Oakdale Ave. Chatsworth		SoCalGas (800) 427-6584
April 28	9:00 a.m. - 5:00 p.m.	**T- 24 Duct Design** (see April 10 for description)		Energy Training Center 1129 Enterprise St. Stockton	Russ King, ConSol	PG&E ETC Karen Lynch (209) 932-2512
April 28	1:00 p.m. - 4:00 p.m.	**Introduction to Design Aspects of Comfort and Efficiency** (see April 12 for description)		SDG&E 8306 Century Park Court Building 4, Room 4120B San Diego	Nehemiah Stone, HMG Deb Allen, D&R International Ken Nittler, Enercomp	SDG&E Debbie Newell (619) 641-7111
May						
May 4	TBD	**Windows Training** Up-to-date information will be provided on the latest developments in high performance window technology including installation practices, standards, and glazing technology recommended by the fenestration industry.	Contractors	McMillin On-Site	James O'Bannon, Phd., RHA	SDG&E

May 5	9:30 a.m. - 11:30 a.m.	**Windows Training** (see May 4 for description)	Contractors	SDG&E 8306 Century Park Court Building 4, Room 4120C San Diego	James O'Bannon, Phd., RHA	SDG&E Debbie Newell (619) 641-7111
May 5	9:00 a.m. - 5:00 p.m.	**T-24 Equipment Sizing & Selecting** (see April 14 for description)		Sierra Energy Center 45 N. Washington St. Sonora	Doug Beaman, Douglas Beaman Associates	PG&E ETC Karen Lynch (209) 932-2500
May 8	9:00 a.m. - 5:00 p.m.	**T- 24 Duct Design** (see April 10 for description)		Energy Training Center 1129 Enterprise St. Stockton	Russ King, ConSol	PG&E ETC Karen Lynch (209) 932-2500
May 8	9:00 a.m. - 5:00 p.m.	**T-24 Air Distribution Diagnostic Testing** (see April 21 for description)		Energy Training Center 1129 Enterprise St. Stockton	Gary Fagilde	PG&E ETC Karen Lynch (209) 932-2500
May 9	9:00 a.m. - 4:00 p.m.	**Title 24 - Manual "J"** (see April 4 for description)		ERC/Downey 9240 E. Firestone Blvd. Downey		SoCalGas (800) 427-6584
May 9	1:00 p.m. - 5:00 p.m.	**T-24 Installation Standards** (see April 20 for description)		Sierra Energy Center 45 N. Washington St. Sonora	Gary Fagilde	PG&E ETC Karen Lynch (209) 932-2500
May 11	9:00 a.m. - 4:00 p.m.	**Title 24 - Manual "D"** (see April 5 for description)		ERC/Downey 9240 E. Firestone Blvd. Downey		SoCalGas (800) 427-6584
May 12	7:30 a.m. - 10:00 a.m.	**Working with SDG&E on Your Building Project** Whatever your project needs, SDG&E will work with you to get the job done. Learn how to get SDG&E involved in your project, what type of information is required for the design of gas and electric facilities, how everything moves through the planning and construction phases and what steps must be taken to ensure your satisfaction with the installation.		Handlery Hotel 950 Hotel Circle North San Diego, CA 92108	Cary Likes SDG&E	SDG&E Debbie Newell (619) 641-7111

May 12	9:00 a.m. - 12:00 p.m.	**Title 24 - Introduction and Overview** (see April 6 for description)		ERC/Downey 9240 E. Firestone Blvd. Downey		SoCalGas (800) 427-6584
May 18	9:00 a.m. - 5:00 p.m.	**Title 24 - Air Balance** (see Mar 30 for description)		ERC/Downey 9240 E. Firestone Blvd. Downey		SoCalGas (800) 427-6584
May 19	9:00 a.m. - 5:00 p.m.	**Title 24 - Air Balance** (see Mar 30 for description)		ERC/Downey 9240 E. Firestone Blvd. Downey		SoCalGas (800) 427-6584
May 19	9:00 a.m. - 12:00 p.m.	**T-24 Comprehensive Code Update for Code Officials** (see April 21 for description)		Hodel's Restaurant 5917 Knudsen Bakersfield	Doug Beaman, Douglas Beaman Associates	PGE ETC Karen Lynch (209) 932-2500
May 23	1:00 p.m. - 5:00 p.m.	**T-24 Installation Standards** (see April 20 for description)		Energy Training Center 1129 Enterprise St. Stockton	Gary Fagilde	PG&E ETC Karen Lynch (209) 932-2500
May 24	9:00 a.m. - 5:00 p.m.	**T-24 Air Distribution Diagnostic Testing** (see April 21 for description)		Energy Training Center 1129 Enterprise St. Stockton	Gary Fagilde	PG&E ETC Karen Lynch (209) 932-2500
May 25	9:00 a.m. - 5:00 p.m.	**T-24 Equipment Sizing & Selecting** (see April 14 for description)		Energy Training Center 1129 Enterprise St. Stockton	Doug Beaman, Douglas Beaman Associates	PG&E ETC Karen Lynch (209) 932-2500
May 26	9:00 a.m. - 5:00 p.m.	**T- 24 Duct Design** (see April 10 for description)		Sierra Energy Center 45 N. Washington St. Sonora	Russ King, ConSol	PG&E ETC Karen Lynch (209) 932-2500

June						
June 2	9:00 a.m. - 12:00 p.m.	**Windows Training – Multi-family** This session will cover the relationship of windows to comfort and efficiency with an emphasis on how to choose the right fenestration products for various multifamily construction styles. Specification conventions and sources of supply for high performance windows will be covered. This session will be of special interest to multi-use project designers.		Handlery Hotel 950 Hotel Circle North San Diego	Nehemiah Stone, HMG Gary Curtis & Jim Russell, D&R International	SDG&E Debbie Newell (619) 641-7111
June 2	1:00 p.m. - 4:00 p.m.	**Modeling Energy Building Performance; Predicting Savings** This is a close look at how multi-family construction practices impact the performance of the building's envelope and systems. We will demonstrate how MICROPAS software can be used to model performance in proposed designs to optimize efficiency.		Handlery Hotel 950 Hotel Circle North San Diego	Ken Nittler, Enercomp Nehemiah Stone, HMG	SDG&E Debbie Newell (619) 641-7111
June 7	8:00 a.m. - 12:00 p.m.	**Building Official Energy Code Training** (see April 25 for description)	Building Officials	Faraday Center 1635 Faraday Avenue Carlsbad	ConSol	SDG&E Debbie Newell (619) 641-7111

June 9	9:00 a.m. - 12:00 p.m.	**T-24 Overview for Architects & Engineers** This half-day class will review the new compliance options in the California Residential Energy Standards. Participants will learn how to use the new compliance options in their residential projects. The new compliance options allow architects and engineers to include low-cost conservation features that either reduce overall construction cost or allow the designer to include design features that were not feasible under the old standards. Participants will learn about the new third party inspection and verification rules for the new compliance options. It is possible using the new compliance to reduce construction cost or increase glazing area in homes and still comply with the energy standards.		Energy Training Center 1129 Enterprise St. Stockton	Doug Beaman, Douglas Beaman Associates	PGE ETC Karen Lynch (209) 932-2500
June 9	9:00 a.m. - 11:30 a.m.	**Windows Training** (see May 4 for description)	Contractors	SDG&E 8326 Century Park Court Building 6, Seminar 1 San Diego	James O'Bannon, Phd., RHA	SDG&E Debbie Newell (619) 641-7111
June 12	9:00 a.m. - 5:00 p.m.	**T-24 Air Distribution Diagnostic Testing** (see April 21 for description)		PG&E Learning Center 3301 Crow Canyon Rd. San Ramon	Gary Fagilde	PG&E ETC Karen Lynch (209) 932-2500
June 12	9:00 a.m. - 5:00 p.m.	**T- 24 Duct Design** (see April 10 for description)		Energy Training Center 1129 Enterprise St. Stockton	Russ King, ConSol	PG&E ETC Karen Lynch (209) 932-2500

June 13	9:00 a.m. - 12:00 p.m.	**Title 24 - Manual "J"** (see April 4 for description)		1919 S. State College Blvd. Anaheim		SoCalGas (800) 427-6584
June 13	1:00 p.m. - 5:00 p.m.	**T-24 Installation Standards** (see April 20 for description)		Energy Training Center 1129 Enterprise St. Stockton	Gary Fagilde	PG&E ETC Karen Lynch (209) 932-2500
June 15	9:00 a.m. - 4:00 p.m.	**Title 24 - Manual "D"** (see April 5 for description)		1919 S. State College Blvd. Anaheim		SoCalGas (800) 427-6584
June 16	9:00 a.m. - 12:00 p.m.	**Title 24 Introduction and Overview** (see April 6 for description)		1919 S. State College Blvd. Anaheim		SoCalGas (800) 427-6584
June 16	1:00 p.m. - 5:00 p.m.	**T-24 Installation Standards** (see April 20 for description)		Energy Training Center 1129 Enterprise St. Stockton	Gary Fagilde	PG&E ETC Karen Lynch (209) 932-2500
June 19	9:00 a.m. - 12:00 p.m.	**T-24 Comprehensive Code Update for Design Community** (see April 21 for description)		Energy Training Center 1129 Enterprise St. Stockton	Doug Beaman, Douglas Beaman Associates	PGE ETC Karen Lynch (209) 932-2500
June 20	9:00 a.m. - 12:00 p.m.	**Comprehensive Code Update for Code Officials** Review of California Residential Energy Standards for building department plan checkers, combination inspectors, and field inspectors. Presenter will focus on the most critical plan and inspection items, and explain rules for HERS and third-party verification and inspection. Discussion will include new compliance options and provide hands-on experience with duct testing.		Energy Training Center 1129 Enterprise St. Stockton	Doug Beaman, Douglas Beaman Associates	PG&E ETC Karen Lynch (209) 932-2500

June 20	9:00 a.m. - 5:00 p.m.	**Title 24 - Air Balance** (see Mar 30 for description)		ERC/Downey 9240 E. Firestone Blvd. Downey		SoCalGas (800) 427-6584
June 20	9:00 a.m. - 12:00 p.m.	**T-24 Comprehensive Code Update for Code Officials** (see April 21 for description)		Energy Training Center 1129 Enterprise St. Stockton	Doug Beaman, Douglas Beaman Associates	PGE ETC Karen Lynch (209) 932-2500
June 22	9:00 a.m. - 5:00 p.m.	**T-24 Equipment Sizing & Selecting** (see April 14 for description)		PG&E Learning Center 3301 Crow Canyon Rd. San Ramon	Doug Beaman, Douglas Beaman Associates	PG&E ETC Karen Lynch (209) 932-2500
June 23	8:30 a.m. - 4:30 p.m.	**HVAC Training** (see April 21 for description)	Contractors Builders	SDG&E 8306 Century Park Court Building 4, Room 4120C San Diego	Russ King, ConSol	SDG&E Debbie Newell (619) 641-7111
June 23	9:00 a.m. - 5:00 p.m.	**T-24 Air Distribution Diagnostic Testing** (see April 21 for description)		Energy Training Center 1129 Enterprise St. Stockton	Gary Fagilde	PG&E ETC Karen Lynch (209) 932-2500
June 26	9:00 a.m. - 5:00 p.m.	**T- 24 Duct Design** (see April 10 for description)		Energy Training Center 1129 Enterprise St. Stockton	Russ King, ConSol	PG&E ETC Karen Lynch (209) 932-2500
June 27	9:00 a.m. - 4:00 p.m.	**Title 24 - Manual "J"** (see April 4 for description)		ERC/Downey 9240 E. Firestone Blvd. Downey		SoCalGas (800) 427-6584
June 29	9:00 a.m. - 5:00 p.m.	**T-24 Equipment Sizing & Selecting** (see April 14 for description)		Energy Training Center 1129 Enterprise St. Stockton	Doug Beaman, Douglas Beaman Associates	PG&E ETC Karen Lynch (209) 932-2500
July						
July 6	8:30 a.m. – 12:00 p.m.	**HVAC** **Equipment Sizing & Selection** This half-day program will bring attendees the specialized knowledge they need to be able to size and select the correct equipment. This course includes: review of		CTAC (Customer Technology Application Center) 6090 N. Irwindale Irwindale	Russ King, ConSol	SOUTHERN CALIFORNIA EDISON Lisa Brewer (626) 302-8707

		the ACCA load calculation and equipment selection process; room by room loads that lead into Manual D Duct Design (compliance credit component); sizing and built in safeguards to "right size" while avoiding undersizing; and review of the ACCA approved software.				
July 6	1:00 p.m. – 4:30 p.m.	**HVAC - Duct Design** This one-day program will bring attendees the specialized knowledge they need to be able to perform the duct design required for compliance credit. This course includes review of the "ACCA Residential Design System;" "Manual D" duct design procedures; optimized design that delivers competitive first cost and comfort; documentation and specification of the duct design; and review of the ACCA-approved software.		CTAC (Customer Technology Application Center) 6090 N. Irwindale Irwindale	Russ King, ConSol	SOUTHERN CALIFORNIA EDISON Lisa Brewer (626) 302-8707
July 7	9:00 a.m. – 4:00 p.m.	**HVAC - Duct Sealing and Testing** Review of new "tight duct" sealing techniques, "Duct Blaster" leakage, demonstrations of air flow properties and other special topics.		CTAC (Customer Technology Application Center 6090 N. Irwindale Irwindale	Russ King, ConSol	SOUTHERN CALIFORNIA EDISON Lisa Brewer (626) 302-8707
July 11	9:00 a.m. – 4:00 p.m.	**Title 24 Manual "D"** (see April 5 for description)		ERC/Downey 9240 E. Firestone Blvd. Downey		SoCalGas (800) 427-6584
July 12	8:00 a.m.-12:00 p.m.	**Building Energy Code Training** (see April 19 for description).	Production Builders	SDG&E 8326 Century Park Court Building 4, Room 4120F San Diego	ConSol	SDG&E Joni (209) 474-8446
July 13	9:00 a.m. - 12:00 p.m.	**Title 24 Introduction and Overview** (see April 6 for description)		ERC/Downey 9240 E. Firestone Blvd. Downey		SoCalGas (800) 427-6584
July 14	1:00 p.m. - 5:00 p.m.	**Energy Efficient Windows Overview** This half-day course will be presented using		Energy Training Center 1129 Enterprise St.	Jim O'Bannon, Phd., RHA	PGE ETC

		both classroom and props to review approved window designs and installation details required in the Residential Contract Program. Students will be made familiar with installation techniques and inspection criteria, which will be required for any home in which windows are installed.		Stockton		Karen Lynch (209) 932-2500
July 20	9:00 a.m. – 12:00 p.m.	**Comprehensive Code Update for Code Officials** (see June 20 for description)		Energy Training Center 1129 Enterprise St. Stockton	Doug Beaman, Douglas Beaman Associates	PG&E ETC Karen Lynch (209) 932-2500
August						
Aug 4	9:30 a.m. - 11:30 a.m.	**Windows Training** (see May 4 for description)	Contractors	SDG&E 8326 Century Park Court Building 6, Seminar Room 1	James O'Bannon, Phd., RHA	SDG&E Debbie Newell (619) 641-7111
Aug 16	9:00 a.m. - 12:00 p.m.	**T-24 Comprehensive Code Update for Code Officials** (see April 21 for description)		Sierra Energy Center 45 N. Washington St. Sonora	Doug Beaman, Douglas Beaman Associates	PGE ETC Karen Lynch (209) 932-2500
Aug 25	8:30 a.m. - 4:30 p.m.	**HVAC Training** (see April 21 for description)	Contractors Builders	SDG&E 8306 Century Park Court Building 4, Room 4120C San Diego	Russ King, ConSol	SDG&E Debbie Newell (619) 641-7111
Aug 28	9:00 a.m. - 12:00 p.m.	**Comprehensive Code Update for Code Officials** (see June 20 for description)	Building Officials	San Francisco, CA	Doug Beaman, Douglas Beaman Associates	PG&E ETC Karen Lynch (209) 932-2500
September						
Sept 6	8:00 a.m.- 12:00 p.m.	**Building Official Energy Code Training** (see April 19 for description)	Production Builders	Chula Vista City Library Auditorium 365 F St. Chula Vista	Russ King, ConSol	SDG&E Debbie Newell (619) 641 7111

Sept 6	TBD	**Builder Energy Code Training** Building Industry Institute (BII) and their subcontractor ConSol, have conducted a training program for large production builders in California and Nevada. This program has improved compliance with energy Standards by improving builders' understanding and implementation of the energy codes. It has also improved the overall quality of the homes and presumably the comfort of the occupants. The major motivating factor for builders to participate in the program is their concern about the construction defect liability that can be incurred when they do not meet building codes.		Fresno Area One-on-one training with builders at their site (as scheduled)	Michael E. Bachand, BII ConSol	PGE ConSol Joni Olarte (209) 474-8446
Sept 7	8:30 a.m. – 12:00 p.m.	**HVAC -Equipment Sizing & Selection** (see July 6 for description)		CTAC (Customer Technology Application Center) 6090 N. Irwindale Avenue Irwindale	Russ King, ConSol	SOUTHERN CALIFORNIA EDISON Lisa Brewer (626) 302-8707
Sept 7	9:00 a.m. – 12:00 p.m.	**Title 24 Introduction and Overview** (see April 6 for description)		ERC/Downey 9240 E. Firestone Blvd. Downey		SoCalGas (800) 427-6584
Sept 7	1:00 p.m. – 4:30 p.m.	**HVAC - Duct Design** (see July 6 for description)		CTAC (Customer Technology Application Center) 6090 N. Irwindale Avenue Irwindale	Russ King, ConSol	SOUTHERN CALIFORNIA EDISON Lisa Brewer (626) 302-8707
Sept 7	TBD	**Builder Energy Code Training** (see Sept 6 for description)		Fresno Area One-on-one training with builders at their site (as scheduled)	Michael E. Bachand, BII ConSol	PGE ConSol Joni Olarte (209) 474-8446
Sept 8	TBD	**Builder Energy Code Training** (see Sept 6 for description)		Fresno Area One-on-one training with builders at their site (as scheduled)	Michael E. Bachand, BII ConSol	PG&E ConSol Joni Olarte (209) 474-8446

Sept 12	9:00 a.m. - 12:00 p.m.	**T-24 Comprehensive Code Update for Code Officials** (see April 21 for description)		Energy Training Center 1129 Enterprise St. Stockton	Doug Beaman, Douglas Beaman Associates	PGE ETC Karen Lynch (209) 932-2500
Sept 14	9:00 a.m. - 12:00 p.m.	**T-24 Overview for Architects & Engineers** (see June 9 for description)		Pacific Energy Center 851 Howard San Francisco	Doug Beaman, Douglas Beaman Associates	PGE ETC Karen Lynch (209) 932-2500
Sept 18	9:00 a.m. - 11:00 a.m.	**Energy Efficiency for Sales Agents** This session will help sales agents become familiar with common energy efficiency technologies for new homes and the benefits they officer homebuyers. Including an overview of program offered by SDG&E.		SDG&E 8326 Century Park Court Building 6, Seminar Room 3 San Diego	David M. Wylie, P.E. ASW Engineering Management Consultants, Inc.	SDG&E Debbie Newell (619) 641-7111
Sept 18	9:00 a.m. - 4:00 p.m.	**Title 24 Manual "J"** (see April 4 for description)		9400 Oakdale Ave. Chatsworth		SoCalGas (800) 427-6584
Sept 19	9:00 a.m. - 4:00 p.m.	**Title 24 Manual "D"** (see April 5 for description)		9400 Oakdale Ave. Chatsworth		SoCalGas (800) 427-6584
Sept 20	6:00 p.m. – 9:00 p.m.	**Title 24 Manual "J" – Evening Class Part 1** (see April 4 for description)		ERC/Downey 9240 E. Firestone Blvd. Downey		SoCalGas (800) 427-6584
Sept 26	9:00 a.m. - 12:00 p.m.	**T-24 Comprehensive Code Update for Design Community** This half-day class will review the California Residential Energy Standards specifically from the standpoint of the design community. The class will focus on how the design community can design the homes they want while still complying with the Energy Standards. Particular emphasis will be placed on the new compliance options that provide the designer with greater design flexibility while achieving energy efficient homes at the same or lower cost than possible under the old standard. The		Pacific Energy Center 851 Howard San Francisco	Doug Beaman, Douglas Beaman Associates	PGE ETC Karen Lynch (209) 932-2500

		class will include a demonstration of duct testing, which is one of the most effective of the new compliance options. Participants will learn about the rules for HERS verification and inspection required with some of the new compliance options.				
Sept 27	6:00 p.m. – 9:00 p.m..	**Title 24 Manual "J" – Evening Class Part 2** (see April 4 for description)		ERC/Downey 9240 E. Firestone Blvd. Downey		SoCalGas (800) 427-6584
October						
Oct 2	9:00 a.m. - 5:00 p.m.	**T-24 Air Distribution Diagnostic Testing** (see April 21 for description)		Energy Training Center 1129 Enterprise St. Stockton	Gary Fagilde	PG&E ETC Karen Lynch (209) 932-2500
Oct 3	1:00 p.m. - 5:00 p.m.	**T-24 Installation Standards** (see April 20 for description)		Energy Training Center 1129 Enterprise St. Stockton	Gary Fagilde	PG&E ETC Karen Lynch (209) 932-2500
Oct 5	9:00 a.m. - 5:00 p.m.	**T-24 Equipment Sizing & Selecting** (see April 14 for description)		Energy Training Center 1129 Enterprise St. Stockton	Doug Beaman, Douglas Beaman Associates	PG&E ETC Karen Lynch (209) 932-2500
Oct 6	9:00 a.m. - 5:00 p.m.	**T- 24 Duct Design** (see April 10 for description)		Energy Training Center 1129 Enterprise St. Stockton	Russ King, ConSol	PG&E ETC Karen Lynch (209) 932-2500
Oct 11	8:00 a.m. - 12:00 p.m.	**T- 24 Duct Design** (see September 6 for description)		Energy Training Center 1129 Enterprise St. Stockton 4 hours Classroom Training	Michael E. Bachand, BII ConSol	PG&E ConSol Joni Olarte (209) 474-8446
Oct. 11	6:00 p.m. – 9:00 p.m.	**Title 24 Manual "D" – Evening Class Part 1** (see April 5 for description)		ERC/Downey 9240 E. Firestone Blvd. Downey		SoCalGas (800) 427-6584

Oct 12	8:30 a.m. – 12:00 p.m.	**T- 24 Duct Design** (see April 10 for description)		CTAC (Customer Technology Application Center) 6090 N. Irwindale Avenue Irwindale	Russ King, ConSol	SOUTHERN CALIFORNIA EDISON Lisa Brewer (626) 302-8707
Oct 12	9:00 a.m. - 4:00 p.m.	**Title 24 Manual "J"** (see April 4 for description)		1919 S. State College Blvd. Anaheim		SoCalGas (800) 427-6584
Oct 12	1:00 p.m. – 4:30 p.m.	**HVAC - Duct Design** (see July 6 for description)		CTAC (Customer Technology Application Center) 6090 N. Irwindale Avenue Irwindale	Russ King, ConSol	SOUTHERN CALIFORNIA EDISON Lisa Brewer (626) 302-8707
Oct 12	TBD	**Builder Energy Code Training** (see Sept. 6 for description)		Stockton area On-Site training as scheduled by Builders (at their site)	Michael E. Bachand, BII ConSol	PG&E ConSol Joni Olarte (209) 474-8446
Oct 13	9:00 a.m. - 4:00 p.m.	**Title 24 Manual "D"** (see April 5 for description)		1919 S. State College Blvd. Anaheim		SoCalGas (800) 427-6584
Oct 13	9:00 a.m. – 4:00 p.m.	**HVAC - Duct Sealing and Testing** (see July 7 for description)		CTAC (Customer Technology Application Center) 6090 N. Irwindale Avenue Irwindale	Russ King, ConSol	SOUTHERN CALIFORNIA EDISON Lisa Brewer (626) 302-8707
Oct 13	TBD	**Builder Energy Code Training** (see Sept. 6 for description)		Stockton area On-Site training as scheduled by Builders (at their site)	Michael E. Bachand, BII ConSol	PGE ConSol Joni Olarte (209) 474-8446
Oct 16	9:00 a.m. - 5:00 p.m.	**T- 24 Duct Design** (see April 10 for description)		Energy Training Center 1129 Enterprise St. Stockton	Russ King, ConSol	PG&E ETC Karen Lynch (209) 932-2500
Oct 17	9:00 a.m. - 5:00 p.m.	**T-24 Equipment Sizing & Selecting** (see April 14 for description)		Energy Training Center 1129 Enterprise St. Stockton	Doug Beaman, Douglas Beaman Associates	PG&E ETC Karen Lynch (209) 932-2500

Oct 18	6:00 p.m. – 9:00 p.m.	**Title 24 Manual "D" – Evening Class Part 2** (see April 5 for description)		ERC/Downey 9240 E. Firestone Blvd. Downey		SoCalGas (800) 427-6584
Oct 19	9:00 a.m. - 12:00 p.m.	**T-24 Comprehensive Code Update for Code Officials** (see June 20 for description)		Energy Training Center 1129 Enterprise St. Stockton	Doug Beaman, Douglas Beaman Associates	PGE ETC Karen Lynch (209) 932-2500
Oct 19	1:00 p.m. - 5:00 p.m.	**T-24 Installation Standards** (see April 20 for description)		Energy Training Center 1129 Enterprise St. Stockton	Gary Fagilde	PG&E ETC Karen Lynch (209) 932-2500
Oct 20	9:00 a.m. - 5:00 p.m.	**T-24 Air Distribution Diagnostic Testing** (see April 21 for description)		Energy Training Center 1129 Enterprise St. Stockton	Gary Fagilde	PG&E ETC Karen Lynch (209) 932-2500
Oct 20	9:00 a.m. - 11:30 a.m.	**Windows Training** (see May 4 for description)	Contractors	SDG&E 8326 Century Park Court Building 6, Seminar Room 1 San Diego	James O'Bannon, PhD., RHA	SDG&E Debbie Newell (619) 641-7111
Oct 27	8:30 a.m. - 4:30 p.m.	**HVAC Training** (see April 21 for description)	Contractors Builders	SDG&E 8326 Century Park Court Building 6, Seminar Room 3 San Diego	Russ King, ConSol	SDG&E Debbie Newell (619) 641-7111
Oct 30, 31 & Nov 1	8:00 a.m. - 5:00 p.m.	**CHEERS** **Title 24/New Construction Rater Training** Certification prepares participants to offer builder Title-24 alternative compliance credits for high performance ducts and infiltration. CHEERS certification is also valid for use with the U.S. EPA Energy State Homes Program.	Energy Consultants	SDG&E 8326 Century Park Court Building 6, Seminar Room 2 San Diego	Doug Beaman, Douglas Beaman Associates	SDG&E Debbie Newell (619) 641-7111
November						
Nov 1	9:00 a.m. - 5:00 p.m.	**T-24 Air Distribution Diagnostic Testing** (see April 21 for description)		Energy Training Center 1129 Enterprise St. Stockton	Gary Fagilde	PG&E ETC Karen Lynch (209) 932-2500

Nov 2	8:30 a.m. – 12:00 p.m.	**HVAC - Equipment Sizing & Selection** (see July 6 for description)		CTAC (Customer Technology Application Center) 6090 N. Irwindale Avenue Irwindale	Russ King, ConSol	SOUTHERN CALIFORNIA EDISON Lisa Brewer (626) 302-8707
Nov. 2	9:00 a.m. - 4:00 p.m.	**Title 24 Manual "J"** (see April 4 for description)		ERC/Downey 9240 E. Firestone Blvd. Downey		SoCalGas (800) 427-6584
Nov 2	1:00 p.m. – 4:30 p.m.	**HVAC - Duct Design** (see July 6 for description)		CTAC (Customer Technology Application Center) 6090 N. Irwindale Avenue Irwindale	Russ King, ConSol	SOUTHERN CALIFORNIA EDISON Lisa Brewer (626) 302-8707
Nov 3	9:00 a.m. – 4:00 p.m.	**Title 24 Manual "D"** (see April 5 for description)		ERC/Downey 9240 E. Firestone Blvd. Downey		SoCalGas (800) 427-6584
Nov 3	9:00 a.m. – 4:00 p.m.	**HVAC - Duct Sealing and Testing** (see July 7 for description)		CTAC (Customer Technology Application Center 6090 N. Irwindale Avenue Irwindale	Russ King, ConSol	SOUTHERN CALIFORNIA EDISON Lisa Brewer (626) 302-8707
Nov 3	1:00 p.m. - 5:00 p.m.	**T-24 Installation Standards** (see April 20 for description)		Energy Training Center 1129 Enterprise St. Stockton	Gary Fagilde	PG&E ETC Karen Lynch (209) 932-2500
Nov 6	9:00 a.m. - 5:00 p.m.	**T- 24 Duct Design** (see April 10 for description)		Energy Training Center 1129 Enterprise St. Stockton	Russ King, ConSol	PG&E ETC Karen Lynch (209) 932-2500
Nov 7	9:00 a.m. - 5:00 p.m.	**T-24 Equipment Sizing & Selecting** (see April 14 for description)		Energy Training Center 1129 Enterprise St. Stockton	Doug Beaman, Douglas Beaman Associates	PG&E ETC Karen Lynch (209) 932-2500

Nov 8	8:00 a.m.- 12:00 p.m.	**Building Official Energy Code Training** (see April 19 for description)	Production Builders	City of San Diego The Ridgehaven Building 9601 Ridgehaven Court San Diego	Russ King ConSol	SDG&E Debbie Newell (619) 641-7111
Nov 8	8:00 a.m. - 12:00 p.m.	**Builder Energy Code Training** (see April 19 for description)	Production Builders	SDG&E 8306 Century Park court Building 4, Room 4120 B San Diego	ConSol	SDG&E Joni (209) 474-8446
Nov 9	9:00 a.m. - 12:00 p.m.	**Title 24 Introduction and Overview** (see April 6 for description)		ERC/Downey 9240 E. Firestone Blvd. Downey		SoCalGas (800) 427-6584
Nov 10	1:00 p.m. - 5:00 p.m.	**T-24 Installation Standards** (see April 20 for description)		Energy Training Center 1129 Enterprise St. Stockton	Gary Fagilde	PG&E ETC Karen Lynch (209) 932-2500
Nov 14	9:00 a.m. - 12:00 p.m.	**T-24 Comprehensive Code Update for Code Officials** (see June 20 for description)		Energy Training Center 1129 Enterprise St. Stockton	Doug Beaman, Douglas Beaman Associates	PGE ETC Karen Lynch (209) 932-2500
Nov 16	9:00 a.m. - 12:00 p.m.	**T-24 Comprehensive Code Update for Design Community** (see September 26 for description)		PG&E's Learning Center 3301 Crow Canyon San Ramon	Doug Beaman. Douglas Beaman Associates	PGE ETC Karen Lynch (209) 932-2500
Nov 16	9:00 a.m. - 5:00 p.m.	**T-24 Air Distribution Diagnostic Testing** (see April 21 for description)		Energy Training Center 1129 Enterprise St. Stockton	Gary Fagilde	PG&E ETC Karen Lynch (209) 932-2500
Nov 20	9:00 a.m. - 12:00 p.m.	**T-24 Overview for Architects & Engineers** (see June 9 for description)		Energy Training Center 1129 Enterprise St. Stockton	Doug Beaman, Douglas Beaman Associates	PGE ETC Karen Lynch (209) 932-2500

Nov 29	9:00 a.m. - 5:00 p.m.	**T- 24 Duct Design** (see April 10 for description)		Energy Training Center 1129 Enterprise St. Stockton	Russ King, ConSol	PG&E ETC Karen Lynch (209) 932-2500
Nov 30	9:00 a.m. - 5:00 p.m.	**T-24 Equipment Sizing & Selecting** (see April 14 for description)		Energy Training Center 1129 Enterprise St. Stockton	Doug Beaman, Douglas Beaman Associates	PG&E ETC Karen Lynch (209) 932-2500
December						
Dec 4	9:00 a.m. - 12:00 p.m.	**T-24 Comprehensive Code Update for Code Officials** (see June 20 for description)		Energy Training Center 1129 Enterprise St. Stockton	Doug Beaman, Douglas Beaman Associates	PGE ETC Karen Lynch (209) 932-2500
Dec 5	9:00 a.m. - 5:00 p.m.	**T-24 Air Distribution Diagnostic Testing** (see April 21 for description)		Energy Training Center 1129 Enterprise St. Stockton	Gary Fagilde	PG&E ETC Karen Lynch (209) 932-2500
Dec 6	TBD	**Builder Energy Code Training** (see September 6 for description)		San Jose area One-on-one with builders at their site	Michael E. Bachand, BII ConSol	PG&E ConSol Joni Olarte (209) 474-8446
Dec 7	TBD	**Builder Energy Code Training** (see September 6 for description)		San Jose area One-on-one with builders at their site	Michael E. Bachand, BII ConSol	PG&E ConSol Joni Olarte (209) 474-8446
Dec 8	1:00 p.m. - 5:00 p.m.	**T-24 Installation Standards** (see April 20 for description)		Energy Training Center 1129 Enterprise St. Stockton	Gary Fagilde	PG&E ETC Karen Lynch (209) 932-2500
Dec 8	TBD	**Builder Energy Code Training** (see Sept. 6 for description)		San Jose area One-on-one with builders at their site	Michael E. Bachand, BII ConSol	PG&E ConSol Joni Olarte (209) 474-8446

San Diego Gas & Electric Training

NONRESIDENTIAL NEW CONSTRUCTION

SDG&E provides recurrent training sessions for nonresidential new construction.

T-24	3/9/00, 6/8/00
EnergyPro - Ltg./Envelope	2/11/00, 5/18/00, 8/17/00
EnergyPro - Mech.	3/10/00, 6/9/00, 9/8/00
EnergyPro - Adv.	5/19/00, 8/18/00, 11/10/00
Daylighting & Productivity Study	4/7/00, 10/6/00
Skylighting Guidelines & SkyCalc	4/7/00, 10/6/00
eQUEST/eVALUator	4/21/00, 7/21/00, 10/20/00
E.E. Central Plant Design Strategies	6/20/00

NON-NEW CONSTRUCTION TRAINING

The first round of Residential HVAC Contractor Training has been completed. The second round is expected to start around the first of September. This is field-based training.

Southern California Gas Training

Date of Training	Type of Training	Target Attendees	Program Type
5/2 to 4/00 06/01/00 08/01/00 10/01/00	ACM/Energy Star	Title-24 consultants	3rd-Party
03/01/00 04/01/00 05/01/00 06/01/00 07/01/00	Installation Standards	HVAC/Insulation Contractors	3rd-Party
03/01/00 04/01/00 05/01/00 06/01/00 07/01/00 08/01/00	ACM/Energy Star	City building officials	3rd-Party

MA&E Study in Support of Codes & Standards

FINAL REPORT
Volume III: Literature Review

PG&E Study ID number: 411

August 31, 2000

Measurement and Evaluation
Customer Energy Efficiency Policy & Evaluation Section
Pacific Gas and Electric Company
San Francisco, California

Market Assessment & Evaluation Study in Support of Codes and Standards

Final Report
Volume III: Literature Review

A Joint Study by Pacific Gas & Electric, San Diego Gas & Electric, Southern California Edison, Southern California Gas and the California Energy Commission

Statewide Project Manager: Mary G. Dimit, PG&E
Project Advisor: William Pennington, CEC

Prepared by
Pacific Consulting Services
1320 Solano Avenue, Suite 203
Albany, CA 94706
510/526-3123

Davis Energy Group
123 C Street
Davis, CA 95616

Eley Associates
142 Minna Street, 2nd Floor
San Francisco, CA 94105

August 31, 2000

TABLE OF CONTENTS

VOLUME III: LITERATURE REVIEW

Current Status of Measure Installation

Key Measures Reviewed

Table 1 lists those residential and nonresidential measures that are either required for standards compliance using the prescriptive approach or are commonly relied on to achieve compliance using the performance approach.

Table 1. Energy Efficiency Measures Typically Used for Standards Compliance

	Nonresidential	Residential
Lighting	Lighting power density Occupancy sensor control Other controls	Kitchen lighting Bathroom lighting
HVAC	Equipment efficiency Equipment part load performance Variable speed fan control Variable speed pump control Economizer Fan system efficiency Equipment sizing Zone control Supply air temperature control	Equipment efficiency Duct design and airflow Duct insulation Duct sealing Fireplace outdoor air source HVAC installation (refrigerant charge, airflow)
Envelope	High performance windows	Envelope sealing and air barrier High performance windows Interior window shades Insulation
Water Heating		Water heater efficiency Pipe insulation

This list of measures served as the basis for our review of measure installation effectiveness. Note that this table does not represent a comprehensive list of all technologies covered by the standards nor does it cover systems not within the scope of the standards (e.g. process systems, elevators, etc.).

Definitions of Measure Installation Effectiveness

Residential Measures

The following list details appropriate definitions of measure installation effectiveness for the residential measures of interest.

- Lighting: kitchen and bathroom lighting efficacy relative to Title 24 Standard of 40 lumens per watt
- HVAC refrigerant charge: charge within approximately 3% of manufacturer's specification

- HVAC system air flow: air flow relative to benchmark minimum of 375–400 cfm per ton
- HVAC duct leakage: Leakage relative to Title 24 standard of less than 6% of nominal fan flow
- HVAC system sizing: not more than 15% greater than Manual J sizing protocols
- Duct insulation: R-value relative to Title 24 minimum of 4.2
- Roof/wall insulation: R-value relative to Title 24 minimum of 13 (wall) and 19 (ceiling), and proper installation to avoid compressions/voids (batt installation) and provide uniform depth (blown insulation).
- Water heating: Energy Factor efficiency relative to Title 24 absolute minimum of 0.53
- Pipe insulation: presence of insulation within 5 feet of water heater

Nonresidential Measures

Studies use lighting power density for measuring lighting efficiency (RLW Analytics 1999; Heschong Mahone Group 1997).

Lighting controls are identified and measured by their prevalence. Examples include percent of lighting power connected to each control type or percent of buildings with specific control types. This is a less than ideal measurement because it does not address performance and is not directly related to energy consumption. Persistence is an important issue with controls. (RLW Analytics, 1999; Heschong Mahone Group 1997)

The effectiveness of HVAC measures is fairly difficult to quantify. Several studies identify the presence of measures along with their nominal efficiency and capacity. So one measure of effectiveness is how frequently systems and equipment required by the energy code are actually installed. But just as with lighting controls, less information is available on actual system performance. (RLW Analytics 1999).

The following list details appropriate definitions of measure installation effectiveness for the nonresidential measures of interest.

- Lighting power density. Title 24 requirements for the relevant building type, typically between 1.0 and 1.8 watts per square foot.
- Occupancy sensor control. Works, not disabled.
- Other controls. Works, not disabled.
- Equipment efficiency. Meets Title 24 requirement (depends on equipment type and size).
- Equipment part load performance. Meets designer's intent and manufacturer's specifications (e.g. a chiller's field performance matches the manufacturer's efficiency claims).
- Variable speed fan control. Fan speed actually decreases (and power consumption drops) as the building loads decrease. Duct pressure control meets designer's intent (typically duct pressure remains constant while airflow and fan speed drop).

- Variable speed pump control. Pump speed actually decreases (and power consumption drops) as the building loads decrease. Requires that cooling and heating coil valves are properly installed and controlled to reduce water flow when load decreases. Also requires that pipe pressure controls are properly installed.
- Economizer. Works (i.e. 100% outdoor air when beneficial for free cooling, closes to minimum ventilation air rate when outdoor temperature exceeds indoor temperature).
- Fan system efficiency. Fan power under Title 24 limit of 1.25 watts per cfm of air flow (for VAV system) and 0.80 watts per cfm (for constant volume systems). Usually possible to do significantly better.
- Equipment sizing. Size equipment appropriately. Follow Title 24 load calculation and system sizing requirements (i.e. equipment must be the smallest size that meets the loads calculated using the guidelines in Title 24)
- Zone control. Minimize use of reheat for zone control as required by Title 24.
- Supply air temperature control. Multizone air distribution systems have functioning controls that raise the cooling supply air temperature when cooling loads decrease.
- High performance windows. U-factor, solar heat gain coefficient (SHGC), and visible light transmittance match the building's design specifications (and Title 24 documentation).

Status of Measure Installation Effectiveness

Residential Lighting

For lighting, kitchen and bathroom lighting are the two main areas where the Residential Mandatory Measures can affect selection of lighting components. For kitchen fixtures, “luminaires for general lighting … shall have lamps with an efficacy of not less than 40 lumens per Watt. Lighting shall be controlled by a switch on a readily accessible lighting control panel at an entrance to the kitchen.” (California Energy Commission 1999). Bathrooms containing a shower must also have at least one light meeting the 40 lumens per Watt efficacy unless the builder decides to trade-off either the utility room, laundry room, or garage for the bathroom. The bathroom trade-off, which first appeared in the 1998 Standards, will likely be widely accepted by builders who have been concerned about the aesthetics of standard magnetic ballast fluorescent lighting. One recent study found that fluorescent lighting was installed in both the bath and the kitchen in about half of a sample of 96 homes surveyed as part of the CEC’s standards monitoring process (Neos 1997).

Prior to the recent change in the Title 24 Standards, the main problem lay with the local building departments not wanting to enforce the use of energy efficient lighting wasn’t popular with the builders and most homeowners (Valley Energy Consultants 1995). If bathroom bar lighting is assumed as a base case (five 60 Watt bulbs), the potential energy use impact could amount to 165 kWh per year per bathroom.

Residential HVAC Systems

A well-designed and installed HVAC system should efficiently maintain indoor comfort in each room of the house. The criteria for a quality HVAC system as defined in the report "Improving the Energy Efficiency of Residential Air Distribution Systems" (Modera and Hammon 1999) includes the following characteristics:

- Proper system and duct sizing to provide correct air flow and meet room-by-room space conditioning loads
- Static pressure drop across the air handler within manufacturer and design specifications
- Sealed and properly sized supply and return duct work
- Balanced air flow between supply and return systems to maintain neutral pressure
- Minimize duct conductive losses to unconditioned space
- Proper refrigerant charge

There are many factors which degrade HVAC system operating efficiency below nominal manufacturer-tested equipment performance. This is especially true of split-system air conditioners, which are by far the most common residential cooling system in California. Four key factors affecting performance include incorrect refrigerant charge, inadequate system air flow, duct leakage, and system oversizing (Neal 1998).

Before industry-wide improvement in the quality of production home HVAC installations can be achieved, the construction industry must recognize that to obtain a better result the builder, and therefore ultimately the homeowner, must be willing to pay for it. The impetus must come either from homeowners demanding it, the state mandating it, utilities or government agencies offering incentives for it, or from a market transformation effort. The last factor would require the building industry to realize that an initial incremental investment in the HVAC system will reap benefits many times larger. The process has begun as the California Building Industry Association Technical Director now recognizes that improved ducts and HVAC installations would result in quantifiable savings to homeowners and offer benefits to builders including reduced callbacks, equipment downsizing, and decreased potential for litigation (Modera and Hammon 1999).

Cooling system sizing has long been a problem for the HVAC industry. Detailed system design methodologies exist for performing room-by-room load calculations and designing duct systems that will satisfy air flow requirements for each room (ACCA 1986, ACCA 1995). Unfortunately for contractors, the sizing procedures assume ideal system installations, such as zero duct leakage (ACCA 1995). This and other idealized assumptions contrary to standard practice have caused contractors learning about a tool which is more time consuming to implement than their current practice. From the contractor perspective, oversizing of air conditioning systems has been the easiest way to minimize homeowner comfort complaints, which in reality are due to a myriad of problems including shortcomings in duct design, excessive duct leakage, inadequate air flow, and improper refrigerant charge. It is easier to ask the builder for more money for something tangible, like a larger piece of equipment, than to solve the underlying issues related to proper design, installation, and commissioning a system, especially since most builders assume they are paying for a quality product. Unfortunately, the practice of oversizing cooling equipment, which has been projected to be as high as 47% over Manual J prescribed sizing (Neme, Proctor, and Nadel 1999), not only results in increased cooling energy use and peak demand, but also requires the homeowner to pay for additional capacity that is not required.

For much of California's populated regions, oversizing is not as big a concern as in other areas of the country. Humid areas need proper system sizing for adequate control of indoor humidity, which is rarely a concern in the dry California climate. In addition, most California residents live in areas where cooling energy use is not high and therefore the economic impacts of oversizing are not overwhelming.

Incorrect refrigerant charge, which was identified as a problem in over 70% of installations nationally, is projected to increase cooling system energy use by 12% (Neme, Proctor, and Nadel 1999). Laboratory testing on one HVAC unit suggests that if the unit could be charged within about 3% of the correct charge, the operating efficiency would remain within 5% of manufacturer's specification (Neal 1998). The magnitude of the charging problem could be greatly reduced by increased use of thermal expansion valves (TXVs) which moderate refrigerant flow much more effectively at atypical operating conditions than the lower cost orifice devices which are common to approximately 70% of the systems sold nationally (Neal 1998). Correct refrigerant charge for installed systems requires improved HVAC contractor training and attention to detail in system commissioning based on the actual lineset length and outdoor conditions. Anecdotal evidence indicates that some HVAC contractors complete a quick refrigerant charge upon system startup, and then wait to hear if the homeowners call to complain about inadequate cooling.

Inadequate air flow over the indoor coil is typically due to reliance on rule-of-thumb duct sizing procedures which result in undersized and overly restrictive duct systems. Standard design practice assumes a nominal air flow of approximately 400 cfm per ton of cooling. Air flow at this level ensures a balance between sensible and latent cooling and provides performance consistent with manufacturer's reported data. In reality, air flows are much lower. Seven studies from throughout the U.S. report an average air flow of 327 cfm per ton, or nearly 20% below manufacturer's recommendations of air flow is realized in residential applications (Neme, Proctor, and Nadel 1999). Based on these studies, it is projected that an increase in air flow to manufacturer's specifications would result in 8% cooling energy savings. Low air flow results in lower supply air temperatures, increased latent cooling (which is unnecessary for much of the dry California climate), and reduced operating efficiency. To obtain system air flows close to manufacturer's specifications, the designer must follow procedures consistent with ACCA's Manual J and D. By following these design procedures, carefully installing the duct system (to eliminate constrictions and excessive bends), and measuring register air flow and duct leakage, adequate air flow can be realized (Modera and Hammon 1999).

Duct leakage is an area which has received much attention in the past few years (Modera and Wilcox 1995; Coito and Syphers et al 1998; Hammon and Modera 1999; Neme, Proctor, and Nadel 1999). Estimates of potential new construction energy savings available from duct leakage remediation efforts range as high as 25% of base-case heating and cooling energy use. (Neme, Proctor, and Nadel 1999).

Current Title 24 default leakage assumptions specify total leakage of 22% of system nominal fan flow, equally divided between supply and return leakage (98 ACM). Duct leakage affects system performance in several ways. Return leakage causes unconditioned attic air to be pulled through the air handler unit resulting in an increased cooling load on the evaporator coil. If 6% of the return air is pulled from a 120°F attic, the system EER is reduced by about 21% (Neal 1998). Supply-side leaks to unconditioned space effectively reduce system capacity. A 4-ton cooling system with 11% supply leakage is literally throwing away nearly a half ton of capacity.

To achieve a "tight" duct system, use of UL181 approved materials (mastics, tapes, sealants, connectors, and closure systems) is required. The CEC has set a 6% duct leakage target as the standard for qualifying for a Title 24 compliance credit. Leakage is typically measured using a duct pressurization device and reported as a percentage of nominal system fan flow (400 cfm per ton). The procedures for performing the duct leakage test are included in the CEC's Appendix F (California Energy Commission 1999).

Duct insulation is another HVAC energy efficiency measure that could be more effectively implemented. Currently, virtually all duct systems in California production homes are R4.2 insulated flex duct. R8 and higher ducts are available but are rarely specified due both to increased cost and the complications of running the larger ducts through tight attic roof trusses and interior wall chases.

The combined impact of the above four factors can be a degradation in HVAC performance of as much as 67% for a 10 SEER system. This assumes all parameters are at worst case performance levels (Neal 1998). A more conservative assumption indicates energy savings potential of 24–35% by correcting these defects (Neme, Proctor, and Nadel 1999).

Residential Envelope Measures

High performance windows can be defined as fenestration which combines a low conductance non-metallic window frame with high efficiency glazing units with low-emissivity surfaces to achieve a low U-value. For climate-specific applications, a low Solar Heat Gain Coefficient (SHGC) can be beneficial. High performance windows typically exhibit different characteristics in hot climates than in cold climates. In hot climates, low SHGC is critical in minimizing solar gains passing through window units. In very cold climates, solar gain is desirable and the design emphasis should be in minimizing the heat transfer (U-value) from indoors to outdoors. High performance windows have gained market share in recent years as incremental costs have fallen from several dollars per ft (of glazing area) to under a $1 per ft.

Unlike interactive measures such as an HVAC system, windows generally provide "as-designed" performance and are usually properly installed. With detailed installation protocols available from the California Association of Window Manufacturers (ConSol 1999), information is available to ensure that field performance achieves laboratory ratings. Since installation of a high performance window is no different than a standard unit, there are no installation issues directly related to the measure. This is one of the key features that makes high efficiency windows palatable to the home builder. For a small incremental cost, a builder can install a product which is visible (and attractive) to the home buyer, with no requirement for diagnostic testing and it's pass/fail uncertainties. A minor inspection complication is that high performance windows now often have two rating factors to compare to compliance documentation. Should (or will) the building inspector pass windows that have a slightly better U-value, but slightly worse SHGC than what was specified?

Interior window shades, specifically roller shades, have become a common method of meeting residential energy compliance in recent years. For builders, roller shades have been an attractive measure since they are low cost, easily installed, and easily verified. For the Energy Commission and many building energy professionals, roller shades have represented a loophole since the longevity of the measure and the reliability of operation have been questionable at best. The 1998 Residential Standards began a phase-out of the roller shade credit. A reduced SHGC (0.47 vs. the default 0.68) can be applied to windows which have an opaque roller shade installed. The SHGC credit is reduced from the level assumed in the 1995 Standards, and will be eliminated January 1, 2002. Elimination of the roller shade credit, although controversial with the building industry, is more consistent with the Energy Commission's goal of eliminating credits for features which require occupant control.

Proper insulation and air sealing of the building envelope is the most basic step in increasing building energy efficiency. Saving one BTU of cooling load at its source is more valuable than saving one BTU at the generating plant due to the numerous inefficiencies encountered in extracting that load from the building. Duct losses, equipment inefficiencies (refrigerant charge, air flow effect on performance), induced building infiltration, transmission and transformer inefficiencies, and generating plant inefficiencies all contribute to load magnification.

Much of California's climate is sufficiently mild that imperfections in the building envelope do not have catastrophic comfort or energy implications. In cold climates serious insulation defects, such as uninsulated wall cavities, contribute to significant comfort problems and possibly frozen plumbing. Therefore they warrant and get significant attention from both installers and code officials. Competitive pricing pressures in the insulation trades in California are evident as minimum wage employees are the most common insulation installers. Limited training and lack of code enforcement on insulation installation quality contribute to a wide range of defects. A comprehensive builder training program completed during 1995-1998 found nearly a third of the houses tested had underinsulated ceilings (or other significant problems) and nearly half of the houses had walls with inadequate insulation, significant insulation compression, or other problems (BII and ConSol 1998). The homes with inadequate ceiling insulation were, on average, 25% short on installed R-value (BII and ConSol 1998).

Tighter enforcement would clearly reduce the number of underinsulated ceilings, since the building official has the authority to disapprove homes with insulation depth below specification. Other problems related to substandard installation quality also need to be addressed. The Energy Commission's ongoing Residential Construction Quality Assessment Project involves detailed diagnostic testing of new homes throughout California. Part of the data collected includes visual and infrared camera inspection of building envelope insulation anomalies. Characterization of wall defects will be analyzed in hot box testing and detailed three-dimensional modeling to be completed at ORNL's Building Technology Center. Results from the ORNL work should provide good quantitative data on effective R-values for typical California wall construction.

Other efforts aimed at improving insulation installation and air sealing practice include the development of envelope protocols (ConSol 1999). This document details common defects and the energy costs associated with them, and provides protocols for the proper installation of insulation and windows, and air sealing techniques to improve the integrity of the building envelope. Builder and subcontractor training integrating these and other protocols have resulted in a significant reduction in the number of envelope defects (BII and ConSol 1998).

Residential Water Heating

Gas water heating is the standard for water heating in California. Electric water heating in new construction is very difficult to implement under Title 24 since source energy calculations are used for water heating. For typical gas water heaters, a minimum Energy Factor efficiency rating of about 0.53 is required. Higher efficiency equipment is often specified as a cost-effective means of achieving compliance. Two studies comparing installed water heater efficiencies with compliance assumptions found discrepancies were common, occurring more frequently than not. However, both studies found that on average the compliance impact was essentially zero since higher Energy Factors were found slightly more frequently than lower Energy Factors (Berkeley Solar Group 1995, Valley Energy Consultants 1996).

Residential Mandatory Measures require installation of pipe insulation on the first five feet of both hot and cold water piping to the water heater. Insulating the lines significantly reduces convective thermosiphoning from the heated storage tank. This measure is frequently not implemented, apparently because inspectors find the insulation to be a fire hazard if it is in close proximity to the water heater flue. Field monitoring of Title 24 compliance issues found this measure was not installed in about 25% of the houses audited (Valley Energy Consultants 1995). The energy use impact of missing pipe insulation is projected to be 3.2 therms per year at typical tank operating temperatures (Davis Energy Group 1991).

Residential Measures with Noteworthy Performance Issues

Based on our literature review of measure installation effectiveness, we conclude that the following measures deserve further scrutiny as candidates for significant performance improvements.

- Bathroom lighting
- Equipment efficiency
- Duct design and airflow
- Duct insulation
- Duct sealing
- HVAC installation (refrigerant charge, airflow)
- Envelope sealing and air barrier

- High performance windows
- Insulation
- Water heater efficiency
- Pipe insulation

Conversely, we have concluded the following measures do not merit further review, either because there are no significant performance issues or because the identified performance issues do not translate into significant energy impacts.

- Kitchen lighting
- Fireplace outdoor air source
- Interior window shades

Nonresidential Lighting Measures

The general conclusion is that most buildings complied with the pre-1998 Title 24 lighting requirements. The average lighting power was found to be equal to or less than baseline by two separate studies. However, one study shows that 10 to 20% of buildings exceed the lighting power requirements.

- A study of commercial buildings in California using data collected between 1992 and 1994 showed that lighting power compliance is good. Data showed that the average lighting power density was 1.48 W/sf. Most building types were close to 1.5 W/sf. Exceptions are restaurants at 2.1, grocery at 1.7 and warehouse at 1.0. The study concludes that actual lighting power is lower than the Title 24 requirements at the time and recommended updating the requirements of the standard to reflect current practice (Title 24 lighting requirements were subsequently updated in 1999). A survey showed that awareness of the code's lighting power requirements is high among lighting professionals. (Heschong Mahone Group 1997)
- Prevalence of lighting controls by control type and building type is reported, but the level of compliance with code requirements could not be determined. Results show that roughly half of the lights in large office and retail buildings have special controls (EMS, time clock, photocell, dimmer, or occupancy sensor). In other building types, 10% to 25% of lighting has special controls. Energy management systems are most prevalent, especially in large office, retail and miscellaneous building categories. Time clocks and occupancy sensors are the other common controls. (Heschong Mahone Group 1997)
- A recent study of nonresidential new construction in California found that lighting power is 24% lower than the Title 24 baseline. These lighting savings account for 9.5% savings compared to whole building baseline energy. Lighting is the majority of the total energy savings of 12.2%. (RLW Analytics 1999)
- Participants in utility programs average 17% better than code (whole building energy), and 88% are better than baseline (12% do not meet code). Non-participants save 11%, and 82% meet the code baseline. (RLW Analytics 1999)

- For lighting, 88% of utility program participants are better than code, and the average is 30% better than code. Eighty percent of non participants are better than baseline, and the average margin is 22%. (RLW Analytics 1999)
- "The number of occupancy sensors being installed has decreased significantly from 1994 [to 1998]. Occupancy sensors have become somewhat unpopular because of their potential to turn off lights while the space is occupied. In the field we found a great majority of people removing and or over-riding the sensor due to poor functionality." (RLW Analytics 1999)
- "The fact that almost 10% of the 1998 sites have this [stepped daylighting] control, is a tremendous increase over previous years, in which less than 1% of the buildings installed this type of control." (RLW Analytics 1999)
- Roughly 25% of buildings have occupancy sensors (primarily offices and schools), and 10% have stepped daylighting controls (primarily retail). (RLW Analytics 1999)

Nonresidential HVAC Measures

Studies show that the average building performs significantly better than Title 24 (according to simulations), but that a significant fraction (20% to 30%) of buildings exceeds the baseline HVAC energy consumption. Since these results reflect only installation and not operation, it is possible that these levels of compliance are optimistic.

- A study of nonresidential new construction in California found that the average building used 25% less cooling energy than a baseline Title 24 building. However, 19% did not meet the Title 24 baseline. [These results are based on DOE2 simulations created from survey data, so they do not necessarily account for operational problems and may overestimate actual savings.] (RLW Analytics 1999)
- Similar results for fan energy show that the average building used 13% less fan energy than a baseline Title 24 building, and 28% did not meet the Title 24 baseline. (RLW Analytics 1999)
- This study also reports the frequency of HVAC system types and shows that packaged units account for 93% of total floor area. Built-up chilled water systems accounted for only 7%. (RLW Analytics 1999)
- Efficiency of packaged air conditioners and chillers is reported to be improving over the last 6 years. (RLW Analytics 1999)
- Five hundred VAV boxes underwent commissioning at Rensselaer Polytechnic Institute (NY) and 288 deficiencies were discovered. The total number of defective boxes is not reported (Angle, Steven, "Rev Up Your VAV", Engineered Systems, Vol. 17, No. 1 January 2000).

Nonresidential Measures With Noteworthy Performance Issues

Based on our literature review of measure installation effectiveness, we conclude that the following measures deserve further scrutiny as candidates for significant performance improvements.

- Occupancy sensor control
- Other lighting controls

- Equipment part load performance
- Variable speed fan control
- Variable speed pump control
- Economizer
- Fan system efficiency
- Equipment sizing
- Zone control
- Supply air temperature control

Conversely, we have concluded the following measures do not merit further review, either because there are no significant performance issues or because the identified performance issues do not translate into significant energy impacts.

- Lighting power density
- Equipment efficiency
- High performance windows

Roles and Attitudes of Key Market Actors

Residential Owners and Home Buyers

The roles and attitudes of home owners and buyers are well described in Barakat and Chamberlin (1997). According to this study, home purchases involve purchases of a package of desirable housing characteristics, including location, number of bedrooms and bathrooms, square footage, lot size, style, energy efficiency, etc.

In principle, homeowners have multiple incentives to purchase energy-efficient homes, including lower energy bills, increased comfort, and greater control of the indoor environment. However, they also face a number of barriers to purchasing energy-efficient homes. An important barrier is lack of information. Many home owners and buyers lack even basic information about the existence of energy-efficient measures. They also lack the information and technical expertise to weigh trade-offs in long-term costs and benefits, assess risks, gauge the credibility of energy efficiency claims, etc. Another serious barrier is the inseparability of home features. Simply put, energy efficiency may not be packaged together with other home features that rank higher on the buyer's list of purchase criteria.

Residential Home Builders

According to RER (1999), production builders are typically large corporations with internal departments and managers who handle a variety of functions including subdivision design and planning, home design, construction, marketing, and sales.

According to Barakat and Chamberlin (1997), home builders (including general contractors and developers) are motivated primarily by economic decision criteria. Their business priorities focus on minimizing construction costs, maximizing home sale values, minimizing construction project time, and minimizing performance problems for which they may be liable after the sale. The same study developed quantitative estimates of the importance builders place on various attributes that contribute to a home's marketability. They found that "[a]s a group, builders perceived location to be the most important criterion, followed by floor plan, sales price, square footage, style, and finally, energy efficiency." Builders' perceptions appear to be generally consistent with study findings regarding home owners.

Builders face several barriers to incorporating energy efficiency into their products. For example, builders do not directly benefit from the bill reductions that result from adopting energy efficiency. Builders are somewhat limited in their ability to analyze the trade-offs among alternative energy efficiency measures. This stems from their reliance on Title 24 consultants, who report energy impacts only as achieving or not achieving code compliance. Finally builders are limited in their ability to specify energy efficiency to bidding contractors.

Residential Designers

Production builders typically develop design concepts internally, typically by a team that includes designers, architects, marketing and sales personnel, and senior management (RER, 1999). Factors that go into the design decisions, include target buyer demographics and home features known to be popular among the target group. Characteristics, such as square footage and number of rooms are designated and passed on to an in-house or contracted architect, who then prepares floor plans and building elevations. Title 24 compliance documents are prepared by a contracted Title 24 consultant, who recommends any needed design changes to the architect.

Residential Contractors

According to Barakat and Chamberlin (1997), contractors are motivated by the need to succeed in competitive bidding processes. Builders evaluate bids on three criteria: cost, ability to meet the construction schedule, and the ability to work without causing the builder undue hassle (e.g., call backs). Thus contractors have an incentive to adopt changes in construction practices that reduce their costs, streamline the construction process, and improve their work product.

HVAC contractors are responsible for determining the specific HVAC equipment and insulated ductwork that will meet the bid specifications. Selection of energy-efficient equipment tends to increase project costs. HVAC contractors are also responsible for determining ductwork sizing, register placement and size, and how the system is balanced. Their decisions are often limited by the need to install ductwork in whatever space is left by the builders, resulting in undersized ducts and numerous corners. HVAC contractors do not generally understand air flows.

Insulation contractors are responsible for determining the specific insulation that will meet the bid specifications. Their decisions are often limited by prior construction decisions. For example, fiberglass batt insulation beyond R-15 typically requires 2"x6" framing instead of 2"x4".

Secondary Market Actors (Residential Sector)
According to Barakat and Chamberlin (1997), realtors play important roles in the home purchase process because "[t]hey are often homeowners' only source of information regarding the characteristics of the homes they are considering and the value of those characteristics. They also often control the sample of homes from which the homeowner chooses to purchase." The report cites realtors' motivations being to enhance their sales commissions, minimize the time it takes to sell a home, and protect their business reputations. Sales commissions are tied to sale prices and sales volume.

The same study also cites mortgage lenders as important sources of influence. Lenders control the amount of money a homeowner can borrow. Unless the lender understands the connection between energy efficiency and the buyer's ability to make mortgage payments, the buyer may have to make trade-offs between energy efficiency and other factors that drive sales price (e.g., size and location). Lender motivations focus on avoiding risk, maintaining the ability to resell mortgages, and earning commissions through up-front points and fees, which generally are tied to mortgage value. As of 1997 there was only a weak secondary market for energy efficiency mortgages in California, consisting of a FHA program and the lenders Country Wide and Norwest.

Nonresidential Building Owners
According to RLW Analytics (1999), owners originate the project but may or may not be the ultimate users of the building. Because owners provide the financing for the work, they have responsibility for final approval of construction details (including any energy efficiency options) and project budgets. The study research findings support the general conclusions that building owner priorities focus on minimizing construction costs, maximizing the value of the finished building, minimizing construction project time, and minimizing performance problems for which they may be liable after project completion.

Nonresidential Designers
According to TecMRKT Works (1998), the role of architects and other design professionals in the nonresidential sector depends on the decision-making model adopted. The report describes three such models: (1) a traditional architect-driven plan/design/build model; (2) the design/build model; and (3) the collaborative model.

In the traditional architect-driven plan/design/build model, design precedes construction. The owner engages an architect, usually through a solicitation or competition, who then develops the schematic and manages development of detailed plans and specifications. Design specialists (typically mechanical, structural, and electrical engineers) are often involved in developing the detailed designs and specifications for the HVAC systems, electrical systems, safety and security systems, etc. With drawings in hand, the owner then solicits bids from contractors to construct the building. In principle, this model makes the owner, architect, and supporting designers the key decision makers in the design process and provides for fully integrated design solutions. In practice, full integration does not always occur.

Design/build models offer the advantage of speed. Design and construction are completed on parallel tracks. This model gives the general contractor an important role in developing design solutions. As a consequence, design tends to be formula driven and the level of analysis and integration may not be very high.

The collaborative model has been developed to address integration and quality issues. In this model, the owner hires an interdisciplinary team of architects, design consultants, and contractors. This approach stresses collaboration and coordination to achieve an optimal combination of cost, quality, function, scope, and time to meet the clients' needs. TecMRKT Works (1998) notes that the commissioning literature discuses the need for integration but does not address how such integration should occur. The report suggests that the collaborative model addresses the need for greater integration in the design/construction process.

General Contractors

As previously indicated, the role of the general contractor depends on the construction model the owner adopts for the project (TecMRKT Works, 1998). Under the plan/design/build model, the contractor has little design responsibility but is exclusively responsible for carrying out the design in the construction phase. In the design/build model, the contractor, the design and construction process occur on parallel tracks. Many decisions that the architect's design team would make in the plan/design/build model, are made in the course of construction by the contractor in the design/build model. In the collaborative model, design issues are fully resolved before construction starts but the contractor has a role in the design process, just as the architects and designers have a role in the construction phase.

Opportunities to Improve Measure Installation Effectiveness

Building Commissioning

Even though building commissioning has yet to become “business as usual”, there is a significant resurgence of interest in commissioning and recommissioning of buildings, which is being driven by energy efficiency and indoor-air quality (Claridge, Haberl et al. 1994).

Extent and nature of building commissioning in the United States

Currently, not much data is available from the literature review on the extent and nature of building commissioning in the state of California. However, several studies have been done on the market for building commissioning in other parts of the United States. Most of the findings are based on the study done for the Northwest Energy Efficiency Alliance by SBW Inc. These studies indicate that

- Estimates based on existing building and new construction data from the Commercial Buildings Energy Consumption Survey and analysis of savings and cost data from 175 commissioning case studies show that less than 5% of all new construction and less than 0.03% of existing buildings are commissioned each year. (Dodds, Dasher et al 1998).
- Commissioning has historically been done for buildings that have complex energy systems, high energy use, or for owners who value a high quality of indoor environment. Examples of such building types include government buildings and complexes, hospital and health care facilities, large commercial

buildings, universities and owners who are responsible for establishing on-going building programs. (Dodds, Dasher et al 1998).

- U.S. Federal government agencies are required to develop a commissioning plan for their buildings. The Canadian government, at least eight state governments (New York, Illinois, Kansas, Florida, Tennessee, Oregon, Washington, and Montana), and some local governments have adopted some form of building commissioning requirement or guideline. Similar practices are being adopted in some private sectors. Small commercial buildings appear to comprise only a minor portion of commissioning (Dodds, Dasher et al 1998, PECI 1998).
- Results from an industry survey conducted for the Electric Power Research Institute (EPRI) indicate that the present infrastructure for providing these services is informal and developing, though very few firms specialize exclusively in building commissioning (Dodds, Dasher et al 1998; PECI 1998).
- A study done by the Northwest Energy Efficiency Alliance (NEEA) indicates that building owners often rely on in-house staff or other vendors with whom they have established business relationships, to conduct functional testing and commissioning activities (including HVAC or controls system design engineer, the HVAC or controls contractor, test and balance contractor, and other independent contractor). For new buildings 22% of respondents said in-house staff had conducted functional performance tests versus 24% who said an independent commissioning agent conducted them (Willems 1999).
- There are a variety of “rules of thumb” in estimating commissioning costs: A Northeast utility company uses $0.20–0.67/sq. ft.; a Northwest utility company uses 6% of the total measured costs; commissioning agents cite costs of 1–4% of total measure costs or $0.01–0.10/sq. ft. (Peterson and Haasl 1994).
- Several organizations (including the Federal government, national laboratories, professional organizations, utility companies) provide support to the industry in the form of technical, demonstration, information, research, educational and training services. (Dodds, Dasher et al 1998; PECI 1998).
- Building commissioning was explicitly mentioned in President Clinton’s Climate Change Action Plan release in October 1993. In addition to this mandate, new Federal initiatives such as the ENERGY STAR Buildings Program of the U.S. EPA and the Federal Energy Management Program of the U.S. Department of Energy (U.S. DOE) also endorse building commissioning (Narel and Haasl 1994).
- A survey, completed by the Energy Center of Wisconsin to understand better the market for building commissioning, indicates that relatively few formal quality assurance procedures are regularly used other than the procedure of verifying the design and installation of building systems, and they do not see quality assurance as an independent formal task. More than half of the interviewees reported that they do not test building systems to assure high quality (York and Sumi 1997).
- Further findings suggest that owners, designers and contractors clearly see the benefits of commissioning and there is a relatively high perception of a demand for commissioning (York and Sumi 1997).

Extent and nature of building commissioning in California

A study done for a Southern California utility found that of the 72 National organizations contacted (that have or are planning to publish commissioning guidelines, standards or data), 42 had developed documents that addressed the commissioning process in some manner. Approximately 44 guidelines, standards, codes or manuals had been published (Dodds, Haasl et al 1994).

- Preliminary phone interviews of “targeted professionals” indicate that all but one of the firms described their experience primarily as systems commissioning.
- Seventy-five percent of the participating firms had primarily commissioned office buildings. All other building types represented less than half of the sample. Fourteen of the sixteen subjects stated that the building they commissioned were owner-occupied; whereas the other two had commissioned only tenant occupied office or industrial buildings.
- The study indicates that the emphases of normal commissioning practices are on HVAC, controls and Energy Conservation Measures. Only two of the surveyed firms verified energy efficiency performance of the building shell.
- The interviews recognize that ‘commissioning’ is not yet a universally understood term in the design/build industry. Performance verification is often used instead of commissioning to describe or sell the service.
- The study also indicates that the owner or the agent of the owner was the driver for securing commissioning services. For the most part, unless they were hired through a utility program, the firms were not hired specifically as commissioning agents. Their role in building performance is usually defined as a design team member and not a test engineer. Although they believe commissioning is a discrete service and should be sold with a separately negotiated fee, they find that this is not always possible.
- The greatest proportion of commissioning time and expense is concentrated on functional testing, including both writing test plans and performing the actual tests. Respondents willing to share cost information indicated they had spent anywhere from 48 hours (small area) to 2000 hours (2.5 million sq. ft complex building) commissioning their largest projects, depending on the size, complexity, number of failures during testing, and the phase of construction at which they entered the process. Regardless of size, all estimates of the amount of time required for performance testing ranged between 40% and 80% of the commissioning project, with an average of about 60%.
- A basis for costing commissioning separately has not been established by most of the firms interviewed. Most participants charged on a time, expenses and materials basis, quoting a not-to-exceed number for all but fixed costs. Generally, a fixed price is not offered although one company provides a cost range ($0.25–$1.25/sf) to give customers an idea of the possible total cost.

- Selection of a representative sample of commercial buildings in Southern California (made using three existing data sets developed by one of the team members) showed that none of them had gone through a formal commissioning process (Refer Figure 1)
- The two Alliance studies (SBW Consulting Inc. 1998; Willems 1999) developed a metric to rate the level of commissioning used in building projects based on owner interviews (SBW Consulting Inc. 1998), and could be used as an important tool in designing the survey queries.

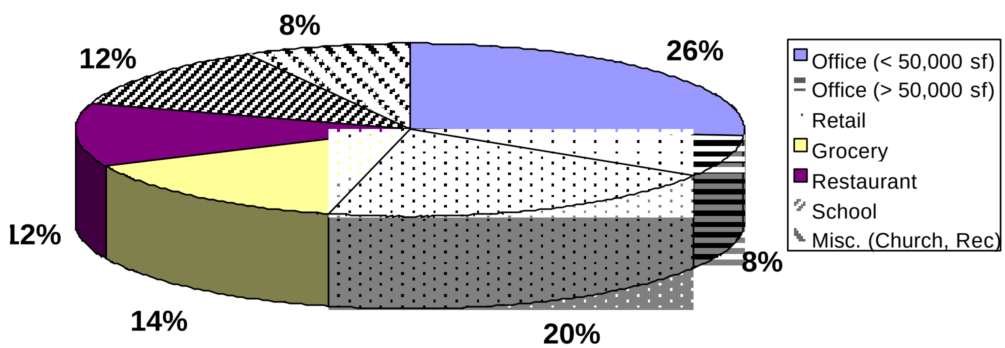

Figure 1. Distribution of the buildings surveyed in the Southern California study

- A similar market research study conducted by the Energy Center of Wisconsin in 1996 could also be a valuable tool in designing the survey (York and Sumi 1997). The research included telephone interviews of sample populations of principal groups involved with design, construction, operation and management of commercial buildings to provide qualitative and quantitative information about the practice of building commissioning. An important aspect of the study is that the term ‘building commissioning’ is not introduced to the participant until well into the interview. This research could also be a valuable tool in designing the survey for California.

Barriers to Building Commissioning

Many studies list barriers to successful commissioning such as

- additional project costs associated with commissioning (Narel and Haasl 1994)
- lack of awareness of the energy benefits and long term economic savings benefits of commissioning (Dodds, Haasl et al 1994; PECI 1998)

- lack of financial incentives (Kunkle, York 1999; Williamson, Koran et al 1994)
- lack of a clear understanding of what building commissioning implies, who are the service providers (Dodds, Haasl et al 1994)
- lack of infrastructure (Dodds, Haasl et al 1994; PECI 1998; Dodds, Dasher et al 1998)
- lack of quality assurance (Dodds, Dasher et al 1998; PECI 1998)
- lack of a standardized methodology and testing procedures that would make the process of commissioning more efficient, cost effective and accessible ((Willems 1999; SBW Consulting Inc. 1998) and making this information available (Dodds, Haasl et al 1994)
- lack of efficient marketing (Dodds, Dasher et al 1998)
- coordination and communication amongst the commissioning team (Willems 1999)
- skepticism on part of building owners and managers that a proposed Energy Conservation Measure (ECM) is going to work (Claridge, Haberl et al 1994)
- extra time and paperwork associated with the commissioning process (York and Sumi 1997)
- lack of mandates enforcing building commissioning (Dodds, Dasher et al 1998)

Since commissioning is not yet budgeted separately, allocating funds for commissioning reduces funds available for other aspects of the project. Equally important is the belief that one should not have to pay extra for the benefits attributed to commissioning (Narel and Haasl 1994). This is because many building owners and managers believe that proper installation of systems or measures should be integral to the construction/ implementation process and a responsibility of the construction team.

The short-run benefit of avoided up-front costs is more attractive than the less clear costs of diminished performance or possible early failure of equipment (Narel and Haasl 1994). This predominantly short-term focus is encouraged by other factors. Most building operators do not actually know how consumptive their buildings are relative to regional or national averages. Even in most buildings with energy management systems (EMS), the systems are not configured to provide operators with short-term feedback on key energy consumption patterns and indicators. The potential of EMS is vastly underused. Finally, tenants are shielded by the cost implications of their energy-use from highly consumptive demands either by full-service leases or ignorance (Narel and Haasl 1994).

One of the primary ways to cut costs is by streamlining the entire process (Yoder and Kaplan 1994). This may be achieved by making existing knowledge on commissioning procedures, and related problems, and tests available to a wider audience. Strategies to achieve this are discussed in more detail later in this section. Another way to reduce up-front costs could be to test new approaches and short-term diagnostic methodologies (Dodds, Haasl et al 1994).

Perceptions that up-front costs outweigh long-term benefits is one of the primary barriers against implementing commissioning (Dodds, Haasl et al 1994; PECI 1998).

One of the primary strategies to overcome this barrier could be to perform a more rigorous technical assessment of commissioning's potential to reduce energy use, sustain a provider industry, and provide cost and savings data to help overcome the current "lack of information" barrier (Dodds, Haasl et al 1994; PECI 1998).

The study done prior to formulating the National Strategy for Building Commissioning (sponsored by the U.S. DOE suggests that the Federal government could serve as an example by commissioning Federal buildings and track costs, savings and benefits of these projects, and then make the findings available to the building industry (Dodds, Dasher et al 1998).

A study sponsored by a Southern California utility company is under way to demonstrate the associated costs and benefits of commissioning typical commercial buildings in Southern California. (Dodds, Haasl et al 1994). We did not find any literature documenting the results.

Besides initiating studies on cost related benefits of building commissioning, the National strategy proposes performing a quantitative cost-benefit analysis of commissioning relative to 'non-energy' benefits (such as improved air-quality, better work environment resulting in higher productivity) and organizing existing cost/benefit case studies for general distribution (Dodds, Dasher et al 1998).

Tax incentives or other financial incentives were identified as another important strategy that the Federal government could use to encourage building commissioning (Kunkle, York 1999). Offering the right financial incentives to the building owner was partly responsible for the success of Clark Public Utilities (Clark County Washington) building commissioning program (Williamson, Koran et al 1994).

Lack of awareness is cited as a key barrier (Kunkle and York 1999). Very often building owners or managers do not know understand what commissioning implies and its benefits, how to implement tests, and who to hire (Willems 1999; SBW Consulting Inc. 1998).

The Alliance study by SBW Inc. suggests marketing the concept of commissioning in terms that owners can understand using financial rather than technical language and also develop a standard definition of commissioning and continue to promote commissioning through national and regional conferences and workshops (Dodds, Dasher et al 1998).

Interviewees suggested that the supply of services (the infrastructure) must be enhanced. The building commissioning infrastructure consists of the service providers and the tools and processes they use to perform commissioning (Dodds, Dasher et al 1998).

There is clearly a need to develop a stronger network of commissioning providers. There is an expectation that the number of service providers will grow as demand for building commissioning increases. The founding of the Building Commissioning Association Northwest offers the first peer organization solely for commissioning providers (Dodds, Haasl et al 1994). However, one needs to carefully assess the need for a national commissioning association as well as alternate approaches. While an association would facilitate a central focus for the commissioning niche, it must avoid creating additional fragmentation of the industry.

An approach could be to enlist the support of insurance companies that serve both owners and industry professional. Because commissioning can reduce claims resulting from improper or inadequate equipment performance and owner dissatisfaction, insurance companies have a stake in promoting the concept of their insured. (PECI 1998)

Quality and consistency of commissioning services is critical to the success of commissioning. Professional certification and a professional association were both suggested as ways to assure customers that they are receiving quality and consistent service. However, the issue of certification for commissioning providers has almost an equal number of supporters as it does opponents. While several participants expressed a need to train more people to provide commissioning services, many cautioned that the pace of developing the infrastructure should not outstrip the demand. This question requires research and may be regional in nature (Dodds, Dasher et al 1998; PECI 1998).

In early 1998, with start-up funding from NEEA, firms providing commissioning services in Washington, Oregon, Idaho and Montana began organizing a regional association through membership application criteria, adherence to a set of commissioning attributes and a peer review process that was initiated by the recipient of commissioning services (Dodds, Dasher et al 1998).

Lack of standardized test procedures or lack of tester certification (performance related uncertainty) is often expressed as a key barrier to commissioning (Willems 1999; SBW Consulting Inc. 1998)

There is a need to enhance the skills of current providers and to respond to growing demand by increasing the number of commissioning providers. An on the job training program was voted as the best method to develop commissioning skills. The complaint against existing standards and training programs was that they provide little more than an introduction to commissioning and the industry lacks a standard source for hands-on training. ASHRAE professional development training seminars and the University of Wisconsin's commissioning courses as were cited as models for future training programs (Dodds, Dasher et al 1998).

Some of the suggestions to develop more effective training programs were as follows:

- Design an internship program to provide commissioning experience to engineering students and recent graduates
- Introducing commissioning into the standard curriculum for architecture and engineering programs.
- Developing one-day lesson plan materials for commissioning to increase the likelihood that faculty would include commissioning in their course work (Dodds, Dasher et al 1998).

Some participants noted the need for additional commissioning information (guide specifications, commissioning plans, guidelines, test procedures and RFPs) for commissioning providers (Dodds, Dasher et al 1998). Common training material developed by the Association of State Energy Research and Technology transfer institute with funding from U.S. DOE was successfully used in the Northwest and Wisconsin (Dodds, Haasl et al 1994).

The Energy FinAnswer Program (launched by Pacific and Utah Power) successfully overcame some of these barriers related to lack of information and updating commissioning techniques by familiarizing commissioning agent candidates on explaining the commissioning process, writing test plans and fulfilling EF documentation requirements. Training the commissioning agents was treated as an ongoing process by continuously updating the commissioning agents on program changes, discussion of program problem areas, and often a presentation of some unfamiliar commissioning technique or system commissioning process and faxing technical bulletins to all commissioning agents. These covered subjects such as safety procedures around electrical equipment, motor testing techniques and use of energy management systems for commissioning (Yoder and Kaplan 1994).

Standard approaches for test plans were developed by collecting a sizable library of representative test plans, networking with heat pump installation contractors (in the Energy FinAnswer Program)—so that small commissioning projects that would require testing that would fall under their range of services can be assigned to a contractor located near the project site. It also included development of a CSI-format commissioning specification that can be integrated into construction specifications. One of the standard approaches to prioritizing task was to sort funded measures and related equipment into three categories—measures that fail without commissioning, but whose commissioning costs outweigh the potential measure savings, measures and equipment that fail without commissioning and whose commissioning costs are justified by the potential measure savings, measures and equipment that generally perform properly with little or no commissioning and tabulating the findings (Yoder and Kaplan 1994). Thus the success of the Energy FinAnswer Program could be largely attributed to increased technical expertise, a growing library of test procedures, more standardization of test procedures, and directing commissioning efforts towards equipment and systems where commissioning is most cost effective. The review of all commissioning technical documentation by the commissioning technical coordinator also helped in aiding the commissioning agents grasp a better understanding of specific Energy FinAnswer program requirements (Yoder and Kaplan 1994).

Although there is a need for additional marketing materials, a number of documents are currently available, but there is no cohesive marketing and distribution strategy for these documents. One needs to identify holes in the current set of marketing/information materials and develop or enhance these materials as necessary and developing an effective marketing and distribution strategy. Conduct cost/benefit and potential studies to develop marketing materials that providers and advocates can distribute to owners. A key strategy to streamlining the process and making it less time-consuming would be to make existing or written software tools widely available—over the Internet or through a commissioning association (Dodds, Dasher et al 1998; PECI 1998).

Poor perception of market needs is also a impediment to making commissioning business as usual There is a need to understand customers perception of value, customer's business objectives, how they measure success, how they are rewarded, and problems they encounter. Selling commissioning would require different approaches as per building type as needs are building specific (Dodds, Haasl et al 1994).

A study done for a utility company in Southern California found that the development of building commissioning product has taken place largely outside of the building industry and has been significantly driven by the needs of the energy-efficiency industry. In other words building commissioning is seen as a response to buildings that do not perform efficiently rather than a response to the need in the market. This ultimately requires those in the building commissioning industry to change by offering a product that meets a market need rather than trying to get the market to change and buy the product we are offering (Dodds, Haasl et al 1994).

It is also felt that most of the strategies discussed in overcoming the market barriers could be enhanced by involvement of the Federal government by the following ways:

- Developing marketing/ information materials to transfer commissioning information to the private sector
- Providing funding for commissioning, demonstration projects, cost-effectiveness studies, promoting building commissioning and commissioning education
- Developing a commissioning curriculum for engineering and architecture programs
- Making commissioning a part of all government performance contracts, especially for military bases
- Incorporating commissioning into current energy programs, such as EPA's ENERGY STAR Building and Labels programs and Green Building's program
- Developing metric for measuring the benefits of commissioning as part of DOE's International Performance Measurement and Verification Protocol (Dodds, Dasher et al 1998).

Lack of communication and coordination among the commissioning team can very often hinder successful implementation of commissioning techniques (Yoder and Kaplan 1994).

Administrative involvement was seen to be a vital force in improving the commissioning process in the Energy FinAnswer program. Communication was vital to the success of the program. Informing both utility personnel and potential customers about the commissioning process and the results from completed jobs and listening and responding to concerns voiced by program managers, the utility sales staff, and customers were key contributors (Yoder and Kaplan 1994). It was found that involvement and commitment by building administrators is a key ingredient for a successful building commissioning program (Claridge, Haberl et al 1994)

Studies done in Texas A&M University found that access by multiple individuals to multiple pieces of equipment caused multiple problems in commissioning. Even after measures were identified and implemented, procedures were needed to assure that the old inefficient practices did not come back (Claridge, Haberl et al 1994)

Very often building owners are skeptical about the effectiveness of suggested measures. There are still building operators who are afraid to turn systems off at night and weekends, or using thermostat setbacks, etc. Building specific information on the savings possible and procedures for initiating shut-offs and monitoring temperatures are needed (Claridge, Haberl et al 1994). In some cases, trial and tests of measures may be needed to assure the staff that it can work and therefore justify the associated cost. This could be done by implementing the measure in phases (for example, phasing the implementation of thermostat setbacks in different zones of the buildings/ building complex), or by citing the effectiveness of the measure from a prior project (Claridge, Haberl et al 1994).

Unaccountability encouraged by codes that do not address commissioning, uneven enforcement of codes that do, and inadequate accountability for problems stemming from poor construction and commissioning practices, make commissioning harder to implement.

As discussed earlier, involvement of the Federal government was voted to be an important factor in the success of commissioning. Most stakeholders seem to concur on the belief that the Federal government should remain an advocate and should not engage in a regulatory role. However, some interviewees did feel that success of commissioning would be enhanced if legislation (e.g., building codes) is enacted (Dodds, Dasher et al 1998). There was no other legal barrier cited in any of the literature reviews.

Opportunities to Improve Measure Installation Effectiveness Through Building Commissioning
Literature review indicates that building commissioning is most effective for measures that are:

- Dependent on digital control systems (Tseng 1994)
- Related to the HVAC system of the building (Waterbury, Frey et al 1994)
- Involve calibration (Reichmuth and Fish 1994; Tseng 1994)

Commissioning is found to be most cost-effective when applied to digital control systems or HVAC systems in the building and least cost-effective when it involves retrofits related to the lighting system the building envelope (Peterson and Haasl 1994).

Owners and facility engineers engaged in the design and construction of buildings all have horror stories about buildings with serious flaws upon occupancy. One of the most common complaints is of HVAC systems not functioning correctly. Annoying problems such as unreliable temperature controls, overheating and overcooling of various zones, lack of credible air-balancing, absence of building pressurization, and poor documentation continue to exasperate the facility engineers long after the building is occupied (Tseng 1994). Effective commissioning of building HVAC and control systems has been increasingly identified as a major factor in ensuring the energy effectiveness of the building. Proper commissioning reduces energy consumption, increases occupant comfort, improves indoor air-quality, and lengthens life of equipment (O' Neill and Radke 1994). Significant amounts of energy are wasted each year in commercial buildings due to inefficient operation of HVAC equipment. Increased energy consumption of 10–35% is not uncommon due to what appear to be minor adjustments to equipment and controls (Waterbury, Frey et al 1994)

Commissioning seems particularly invaluable in buildings where most of the recommended energy measures depend on operating schedules and digital controls, or projects that involve calibration and recalibration of various controls (Reichmuth and Fish 1994; Tseng 1994).

While commissioning often reveals malfunctions in the building that cause the actual energy savings to fall short of the predicted energy savings (if ECMs were implemented prior to commissioning), it is equally common to find that the energy savings were over-predicted in the first place. This situation is typically found to occur when a building has undergone a traditional audit procedure prior to recommending the ECMs. The auditors are often unfamiliar with the operations of a building, due to insufficient data. There isn't enough documentation or other reliable source of information available to closely simulate the actual functioning/ operational schedules of the building (Claridge, Haberl et al 1994)

Typical opportunities for energy measures identified during the commissioning process and the most effective measures are described in the following case studies.

The Texas LoanSTAR program identified $4 million savings from measures in various buildings, 80% of which were opportunities that were identified during a commissioning process after a traditional audit procedure and retrofit had been implemented. Implementation of measures identified by continuous monitoring resulted in another 15% savings over the 30% savings achieved with the first set of measures installed (Student Recreation Center, Texas A&M University). Savings (worth 11.5% of annual energy cost) were identified for 8 state government buildings in Austin, Texas, but not implemented until the building commissioning stepped in.

The LoanSTAR program funded conversion of four-lamp fixtures to two-lamp fixtures with 45 schools in a large school district in Austin, Texas. Building monitoring revealed that savings were only half to two-thirds of the predicted savings. On commissioning it was found that the EMCS had been disabled at various points in the school. Similar findings were made in other buildings recommissioned by them. Recommissioning identified and implemented measures that reduced consumption by 31% in a medical research building in Houston, Texas. An additional 44% reduction was identified but not implemented during the recommissioning process.

Sometimes savings can be lower than predicted due to errors during the audit procedure. For example, three campus buildings at a University campus in the Dallas-Fort Worth metroplex had a measured savings between 25–62%. Commissioning revealed that the auditors had overestimated the annual hours of operation and used the rated power for the AHU versus the actual power draw.

Savings of $3.5 million/ yr. were identified in buildings which had already been retrofitted in the LoanSTAR project. Measures producing savings at an annual rate of $780,000 have been fully implemented. The O&M measures identified total 23% of the total energy costs at the facilities surveyed. The average LoanSTAR facility undergoing retrofit had saved 27% of its energy use as of the end of 1992 with a payback of slightly over 3 years. These savings were approximately 25% more than predicted by the pre-retrofit audits. It appears that the building commissioning program will have savings that will exceed 150% of predicted retrofit savings. However, even after measures were identified and implemented, procedures were needed to assure that the old inefficient convenient practices did not come back.

ShinEtsu America EPI facility in Clark County, Washington was one such project where commissioning uncovered many potential energy saving measures, many related to the HVAC system of the building. (Williamson, Koran et al 1994)

One of the primary changes was made to the water and air systems resulting in an annual energy savings of 19%. The changes involved alterations to the larger pipes and ducts, low pressure drop filters and coils and premium energy efficiency motors and pumps. Increasing the efficiency of chillers resulted in further savings of 10%.

Variable frequency drives were specified to vary the speed of the pump and fan motors according to the load resulting in annual savings of 6%. In some cases, where a variable speed drive had already been installed, it was found to operate at full load all the time and design air-flow was not achieved. Similarly, variable speed drives on the chilled and hot water pumps were found to operate at nearly constant speed.

An opportunity discovered during the commissioning process was to regulate the pressure of condenser water and primary chiller loops by bypassing the flow around the load causing the pump flow to be fairly constant. Energy savings may occur when the flow around the load is allowed to vary with the load. The engineers at SEH had overlooked this possibility and installed variable frequency drives on the condenser water and primary chilled water pump. The commissioning engineers recommended varying the pump speed to regulate pressure rather than opening and closing the by-pass valves.

Another recommendation was to include a water side economizer capability (free cooling) which resulted in annual energy savings of 5%. There were some anomalies discovered during the commissioning process. The valve used to control the supply during the total freeload cooling was cycling from full open to full closed indicating that the controls algorithm needed tuning. Also, the two valves used to control the supply temperature during the partial free cooling were not controlled, but they remained 50% open during all conditions. This reduced the capacity during total free cooling by 50% and forced the chiller to come on at very low load when it would have otherwise remained off.

It was also discovered that the control set-point and chilled water piping were not optimized. They were not set-up to integrate the economizer and the chiller and would not take full advantage of the potential for partial free cooling. The commissioning engineer estimated that changing the control set points would save 97,000 kWh annually. An annual savings of 390,000 kWh were estimated from the previous and changes in the leaving chilled water temperature and larger chilled water coils. The secondary chilled water temperature was also reset.

More problems were detected with the air-handling equipment. The chiller temperature sensor and two condenser water temp sensors were out of calibration.

Retrofitting the building with an energy efficient lighting system accounted for only 0.4% of the annual savings.

A 311,000 sq. ft. building was comprehensively retrofitted to achieve a verified savings of 33%. A principal feature of the retrofit was a digitally based control system employing more than 3,500 sensor and control points (Reichmuth and Fish 1994).

A study was done to evaluate the effectiveness of the recommended Energy Conservation Measures (ECMs) for a 75,000 sq. ft. building in the Pacific Northwest. The ECMs were incorporated at the design phase and the objective of the ECMs was to use at least 30% less energy than a baseline building that meets Model Conservation Standard Code (Peterson and Haasl 1994). The building was commissioned three years after occupancy.

Due to disabled or malfunctioning measures, the building energy savings did not approach the design phase estimate of 40.1%. It was also found that some of the savings were overestimated. The final annual energy savings for the building were calculated to be 25.1% after commissioning.

Based on commissioning the cost-effectiveness of the proposed ECMs were re-evaluated using three approaches, as follows:

- The cost-effectiveness of the ECMs was recalculated with predicted energy savings between the ideal model and the MCS baseline.
- The cost-effectiveness of the commissioning as a measure was derived from energy savings between the tuned model and the ideal model using the commissioning cost-estimate.
- The 3rd approach looked at the ECMs and commissioning as a package and derived cost-effectiveness based on energy savings between the baseline and the ideal models and the incremental ECM cost plus commissioning costs.

Of the eight ECMs proposed in the initial design phase only five were commissioned and the others were discarded as not being cost effective.

The least efficient measures included (starting with the least cost-effective measure):

- An energy efficient lighting system
- Installing occupancy sensors
- Improving the roof insulation

The ECMs that were implemented (starting with the most cost-effective) were related to:

- The Hydronic Loop
- Window shades
- Improving the wall insulation
- Exhaust Fan control
- Energy Management and Control System

In 1994, the state of Tennessee began to explore the benefits of building commissioning to better understand how existing system commissioning would improve the state building performance. The Chattanooga State Office Building was commissioned and forty-five possible improvements were identified, most of which related to the HVAC system, the Energy Management and Control System, and the domestic hot water system. Fifty-five percent of the improvements have been implemented (Edmunds and Haasl 1998).

The total cost of the project for installing both new ECMs and commissioning existing building systems was $110,000, with annual energy savings of $60,000 resulting in a payback period of 22 months (less than 2 years).

Other case studies and reports identify typical payback period due to commissioning as 2–3 years (Tseng 1998).

Diagnostic Testing and Third Party Inspections

Extent and Nature of Diagnostic Testing and Third Party Inspections

Based upon our literature review, it appears that the preponderance of diagnostic testing and third party inspections currently being conducted on residential construction is done in association with energy efficiency programs administered by a utility or governmental agency. This includes testing and inspections required by certain energy efficiency programs (e.g., Comfort Home, ENERGY STAR) as well as measurement, assessment and evaluation work done to assess the effectiveness of those programs. In addition, diagnostic testing and third party inspections are done as part of CEC studies and projects (e.g., the Residential Quality Assessment Project currently being completed by Davis Energy Group) and to assess the level of compliance with Title 24. The literature does not indicate a significant amount of diagnostic testing or third party inspection work being done at the impetus of builders or HVAC contractors seeking to enhance quality control on their own. This needs further investigation, however, as the authors are aware of at least one firm that conducts house inspections for builders for quality control purposes.

Until the mid-1990's, house inspections, surveys and audits did not include any significant testing. Audits measured the characteristics, size and capacities of various parts of the house and the appliances and equipment included in it. These included, for example, the sizes of windows and walls, the R-values of insulation, the capacities and efficiency ratings of furnaces and air conditioners, and the number and kind of lights.

In the mid-1990's, some of the testing and inspection work done to measure the effectiveness and accuracy of utility energy efficiency programs and Title 24 compliance models included tests of duct and envelope leakage. More recently, some energy efficiency programs (e.g. ENERGY STAR) require duct and envelope testing. This testing typically involves use of duct blaster tests, blower door tests, and/or flow hood measurements.

Barriers to Diagnostic Testing and Third Party Inspections

Diagnostic testing and third party inspections face many of the same barriers that energy code enforcement faces in general. These include (Verdict, Fairey, et al 1998):

- Builder resistance to government regulations and changes in building practices
- Perceived complexity of the energy code
- Lack of familiarity by code officials, designers, builders and others
- Lack of resources for adequate enforcement
- Lack of appreciation of the energy impacts of building practices

Another general barrier to compliance with energy codes is the feeling among many building inspectors that it is not their job to ensure that buildings comply with energy codes. Instead, they believe their job is to enforce compliance with health and safety related codes. (Williams, Horgan, et al 1997) Finally, perhaps because of the barriers previously enumerated, compliance and enforcement of the energy code varies significantly by climate zone in California. This presents another potential obstacle: a perception of a lack of consistency, and therefore fairness.

When contemplating why there is an apparent lack of priority and resources applied to energy code enforcement, it might be useful to consider the level of priority attributed to energy efficiency by the ultimate decision-makers—the buyers of new houses. The majority of home buyers do not base their decision on accurate information and analysis of the cost effectiveness of various energy efficiency measures. (Wirtshafter and Hildebrandt 1992) This could be because the perceived added cost of owning a non-energy efficient home is low. According to a study of new California homes completed in 1997, noncompliance with Title 24 adds only an average of $80 per year, less than $7 per month, to household costs (NEOS Corporation 1997). This is under the radar screen of most households.

Other general barriers to greater energy efficiency in residential construction include (Herman, Khawaja, et al 1997):

- Builders do not see financial benefits from installing measures that exceed code. They believe it will cost more and will not provide sufficient benefits in terms of marketability of the home.
- Lenders value the ability to resell mortgages. At present there is only a weak secondary market for energy efficiency mortgages in California.
- Realtors are not familiar with energy efficiency measures and do not know how to value them.

Beyond general barriers, there are some barriers that are specific to diagnostic testing and third party inspections. The house sampling techniques calling for the testing of some but not all homes included in some tight duct programs (e.g., ENERGY STAR) is raising the ire of HERS raters throughout the country (Werling, Hall et al 1998). On the positive side, as the number of houses tested and inspected by third parties increases, this barrier will dissipate. Other market barriers to diagnostic testing and third party inspections include:

- Lack of infrastructure, trained testers, inspectors and HERS Raters
- The need for specialized equipment and training, and its cost
- The need for consistent methodology
- The cost of tests, inspections and required remedial action
- Concern by subcontractors that third party testers and/or inspectors will report defects to their builder clients in a manner that is adverse to their interests

On another positive note, on-site training in diagnostic testing completed between 1995 and 1998 in California and Nevada was very popular with builders and their subcontractors. Contractors who thought that they were installing tight ducts could see where and how much leakage was occurring (Buildings Industry Institute and ConSol 1998). Apparently, as the level of knowledge increases, so does the level of appreciation for diagnostic testing.

Opportunities to Improve Measure Installation Effectiveness Through Diagnostic Testing and Third Party Inspections

One of the prerequisites for the successful implementation of a program that promotes greater energy efficiency in houses is a perception of fairness. This is true whether the program is related to code enforcement or incentives for greater energy efficiency. For example, some governmental jurisdictions have experimented with varying electric utility connection fees with the measured energy efficiency of the house. A program such as this requires a precise measurement of energy efficiency for its implementation. Some in the industry are not convinced that a HERS rating alone is a precise enough measuring device on which to base the size or determination of incentive payments. It is felt that when a blower door test is combined with a HERS rating, however, the necessary precision can be attained (Wirtshafter and Hildebrandt 1992).

Perhaps the strongest opportunity offered by the use of diagnostic testing is that the most widely discussed tests measure the effectiveness of systems that promise the most cost effective energy efficiency. Simulation results indicate that the most cost-effective energy efficiency measure is the reduction of outside air infiltration. A number of varying steps can be taken to reduce outside air infiltration, however, the effectiveness of all of them can be measured using a blower door test (Wirtshafter and Hildebrandt 1992). Another study indicates that 30% to 40% of residential HVAC energy consumption is lost through leaks in the ducting system due to poor installation. Seventy-five percent of the air loss was from the supply ducts and 25% of air loss was attributed to the return ducts (Syphers, Lekov et al 1998). Duct tests are also among the most widely discussed in the literature. The need for diagnostic testing of ducts is underscored by the wide variation observed in duct system efficiency and envelope leakage levels in different houses (Wray, Piette et al 1999).

Another argument in favor of third party inspections and diagnostic testing is the generally low compliance rate found in California houses. Title 24 compliance studies completed in the mid-1990's found many discrepancies. For example, a 1994 study of 133 buildings found that every building had at least one Title 24 discrepancy. 35 of the 93 residential buildings monitored did not meet overall energy standards. A total of 1,478 discrepancies were found, averaging 16 per building. (Valley Energy Consultants 1994) Although this may also reflect the complexity of Title 24 and/or the lack of enforcement on the part of building code officials, it still would indicate a need for further testing or inspection of buildings to enhance energy efficiency. A similar study completed in 1995 found that 70% of 96 audited houses overstated the efficiency of one or more of five key energy measures (Vine 1996). By comparison, homes participating in the Comfort Home Program, which has a third party inspection and testing component to it, were found to be more energy efficient as measured by Title 24 compliance and duct efficiencies. Participating homes were found to have a Title 24 compliance margin of 14.2% versus 7.6% for non-participating homes (Eley Associates 1994). Perhaps the next step should be the completion of an analysis of the costs and energy saving benefits that would be associated with a broad based third party inspection and diagnostic testing program.

Financing and Liability

This section describes "lessons learned" from our in-depth literature review about energy efficiency financing and insurance, and how they relate to codes and standards. It should be noted that most of the literature we reviewed addressed the residential sector; we found very little that was specific to the commercial side. Therefore, the following information primarily applies to residential applications.

Links to Liability Concerns

Relationship Between Energy Efficiency and Liability Concerns

There are eight types of physical problems that relate to insurance losses, according to "Energy-Efficiency and Renewable Energy Options for Risk Management and Insurance Loss Reduction: An Inventory of Technologies, Research Capabilities, and Research Facilities at the U.S. Department of Energy's National Laboratory (Vine et al 1998), as follows:

- Extreme temperature episodes: extreme weather conditions that cause broken water pipes or "urban heat catastrophes" and loss of life.
- Fire and wind damage: the malfunctioning of heating or lighting equipment can lead to fires, sever property damage, and loss of life, as well as high winds from tornadoes and hurricanes.
- Home or workplace indoor air quality hazards: for example, carbon monoxide from improperly installed ducts and malfunctioning appliances can cause illness or death.
- Home or workplace safety hazards: for example, energy-efficient lighting often leads to fewer fixtures being installed as well as fewer changes in fixtures and lamps, thus reducing the safety hazards associated with lamp and fixture replacement (e.g., CFL lamps v. incandescent and LED exit lights v. incandescent exit lights).

- Ice and water damage: for example, repeated melting and re-freezing of snow can cause the formation of icicles and ice dams on roof eaves. Melting water “ponds” on roof tops and can damage the roof and even the interior.
- Outdoor pollution or other environmental hazards: for example, oil from transformers, mercury from lamps, and heavy metals from metal processing can harm both the environment as well as the workers handling these materials.
- Power failures: for example, when power service is disrupted due to storms or other events, service interruptions often result. Losses from service interruptions can account for 20–40% of total insured losses, according to this study’s findings.
- Theft and burglary: poorly designed windows can facilitate theft and burglary in homes.

Types of liability insurance related to energy efficiency include:

Boiler and machinery risk: this form of insurance provides important mechanical breakdown coverage generally not available under any other insurance policy. This type of insurance policy can protect an insured against the effects of catastrophic property loss, such as explosion or expensive breakdowns. According to LBNL, the best ways of avoiding mechanical breakdowns is making sure the equipment is designed and installed properly and that any equipment is in compliance with existing standards or guidelines, the focus of building code development and compliance.

Builder’s risk: Builder’s risk insurance indemnifies for loss of, or damage to, a building under construction. This type of insurance is normally written for a specified amount on the building and applies only in the course of construction. Coverage typically includes fire, extended coverage, vandalism, and malicious mischief. One of the best ways for reducing builder’s risk is through building code development and compliance, as well as many of the integrated information technologies described in this report, energy management and control systems, building commissioning, architectural and infrastructure surety, and measurement and verification protocols.

Business interruption coverage: This type of insurance provides loss of income coverage for a business by replacing operating income during the period when damage to the premises or other property prevents income from being earned. The purpose of the insurance is to ensure the business meets its expenses of payroll, light, heat, advertising, telephone service, etc., from which a profit is derived. Business interruptions include fire, lightning, water damage, etc. There are several ways to reduce insurance losses from business interruptions such as explosion prevention technologies, ultraviolet water purification, refractories in glass production furnaces, and even reduction of cracking in recovery boilers in pulp and paper mills.

Commercial property insurance: Commercial property insurance policies provide indemnification to the policyholder for direct damage to insured structures and business personal property. Direct damage to insured structures and business personal property includes payment for the repair or replacement of the damaged property. Ways to reduce insurance losses due to commercial property damage include integrated information technology (LBNL), energy management and control systems, building commissioning, architectural and infrastructure surety, and measurement and verification protocols. Energy efficient technologies that can reduce commercial property insurance include: efficient duct systems, light-colored roofs, energy-efficient torchieres, explosion prevention technologies, wind-resistant building envelopes, durable roof coating materials, and efficient motors.

Completed operations liability: This form of liability insurance provides coverage for bodily injury and property damage arising from completed or abandoned operations, provided the incident occurs away from premises owned or rented by the insured. The best way of avoiding these problems is making sure the equipment is designed and installed properly, the focus of building code development and compliance, as well as standard measurement and verification protocols. In addition, because indoor air quality illnesses can result in large insurance losses, reducing the strength of indoor pollutant sources is commonly the best method to reduce indoor air pollution.

Comprehensive general liability: This form of insurance means that the insurance company will pay all sums the insured becomes legally obligated to pay as damages due to bodily injury and property damage.

Contractors liability: Contractors are liable for damages resulting from bodily injury and/or property damage caused by an insured peril and arising out of the ownership, maintenance, or use of premises and operations in progress. They are also liable for bodily injury and/or property damage after their work is completed and they have left the job site. This type of insurance covers people who are working on a particular construction site, in contrast to professionals who may not be at the construction site (e.g., architects and engineers). Building code development and compliance, measurement and verification protocols, energy management and control systems, building commissioning, as well as reduction of indoor air pollution and radon resistant housing are all examples of how this type of insurance loss can be avoided.

Environmental liability: Several energy-efficiency technologies and services help to reduce environmental liability risks. For example, by replacing oil-filled transformers with superconducting transformers, there may be fewer liability concerns with the handling and leakage of oil, as well as problems with transformers that are cooled with oil. Similarly, the replacement of chlorofluorocarbons (CFCs) by advanced thermal insulation (e.g., evacuated panel superinsulations and non-HCFC-blown plastic foam insulation) will reduce potential liability claims related to the handling and/or leakage of CFCs in buildings. Installing composite wall systems reduces the exposure of children to lead poisoning hazards in residential housing. Finally, sulfur lamps do not use mercury, thereby eliminating insurance claims related to the handling or disposal of mercury

Health/life insurance (commercial): Examples of technologies and services that reduce losses under health/life insurance include the following: building commissioning and building code enforcement, light-colored roofs and surfaces, daylighting, technologies for clean rooms, radon resistant housing, composite walls, and energy-efficient torchieres. Other technologies not previously described include the improvement of oil-fired combustion systems, including the reduction of fouling and corrosion of heat exchangers, as well as the training and certification of oil-fired heating system service personnel to make sure the equipment is operating as designed.

Product liability: Product liability is the liability for bodily injury or property damage incurred by a merchant or manufacturer as a consequence of some defect in the product sold or manufactured, or the liability incurred by a contractor after he has completed a job as a result of improperly performed work. Building commissioning is a process that should reduce product liability claims by making sure that equipment (and the building) is operating as designed. Energy-efficient torchieres (instead of halogen torchieres) represent a specific technology that will significantly reduce product liability claims, since halogen torchieres account for about 10% of residential lighting use in the United States.

Professional liability: Professional liability insurance is coverage for liability resulting from errors or omissions in the performance of professional duties. This is applicable as a general rule to professional business activities, typically not at the construction site. In addition to the integrated information technologies, (e.g., integrated information technology, energy management and control systems, building commissioning, architectural and infrastructure surety, and measurement and verification protocols, several energy-efficiency technologies and services help to reduce contractors liability, such as reduction of indoor air pollution, radon-resistant housing, and geographic information systems.

Service interruption coverage: Similar to business interruption coverage, this form of insurance provides loss of income coverage for a business by replacing operating income during the period when damage to the premises or other property prevents income from being earned. Similarly, cool storage systems are used in commercial buildings to shift the cooling load of a building to offpeak periods during the day. If a building's chiller or refrigeration system were to fail and the storage system could provide more than 12 hours of air conditioning without chiller operation, this would possibly provide time for the chiller to be repaired or for alternative cooling arrangements to be completed. Any insured losses associated with building operation might be avoided. If the storage system provides less than 12 hours of air conditioning without chiller operation, benefits would still accrue, as uninsured or self-insured losses would be less.

Workers compensation: Workers compensation insurance protects the employee and the employer from the expenses and liabilities associated with a work-related accident. Many energy-efficiency technologies and services help to reduce worker's compensation claims: for example, building commissioning and energy management and control systems ensure that equipment is operating as designed. The reduction of indoor pollutant sources should reduce worker's compensation claims by improving the indoor air quality and health of workers

Health/life insurance (Residential) and personal liability: Many of the energy efficiency technologies and services that reduce commercial lines of coverage also reduce exposures under personal lines of coverage, especially with respect to health and life insurance and personal liability. Examples include the following technologies and services: building commissioning and building code enforcement, light-colored roofs and surfaces, daylighting, technologies for clean rooms, radon resistant housing, composite walls, energy-efficient torchieres, the improvement of oil-fired combustion systems, including the reduction of fouling and corrosion of heat exchangers.

Homeowners insurance: Several energy efficiency technologies and services can help reduce homeowners' insurance claims: e.g., light-colored roofs and surfaces (by reducing heat-build-up in the attic) and energy-efficient torchieres (reducing fire hazards from halogen bulbs. Duct systems in houses typically leak 15–30% of the air passing through them, impacting safety, energy use, indoor air quality, personal comfort and the environment. Improving the performance of duct systems and using aerosol sealing for internally sealing air leaks in heating and cooling ducts can avoid fires caused by furnace flame roll-out. The training, testing and certification of service technicians has aided in the safe long-term operation of oil-fired heating equipment.

Barriers to Liability Concern Linkages
Our literature review did not uncover liability-related barriers.

Opportunities to Improve Measure Installation Effectiveness Through Liability Concern Linkages
According to our literature review of current research, there are numerous opportunities to improve the effectiveness of measure installation through liability concerns. The following presents our findings, and stems mostly from Lawrence Berkeley Lab research. (Vine et al 1999).

A main concern with measure installation and liability is that of reliability, or interruption of power as a result of measure failure. Several technologies can help reduce business-interruption losses:

- Explosion-prevention technologies can eliminate the need to coat sensitive surfaces, reducing manufacturing costs. These technologies can prevent property damage and void business interruptions.
- Energy-efficient ultraviolet water purification can produce emergency potable water during disaster situations, allowing businesses to continue to operate.
- Refractories in glass-production furnaces can extend the life and minimize the down time for these furnaces.
- The reduction of cracking in recovery boilers in pulp and paper mills also will maximize the service life and minimize downtime.

Other energy-efficient technologies that can reduce the potential for loss include wind-resistant building envelopes, durable roof coating materials and efficient motors. For example, halogen floor lamps are extremely energy intensive and operate at very high temperatures, creating a significant fire hazard. They have been the source of 350 reported house fires, 30 deaths and 114 nonfatal injuries in recent years. An additional 100 fires occurred at U.S. colleges and universities in 1996 and 1997. A safer, energy-efficient replacement torchiere is now available and consumes only 60 to 80 watts, compared with 300 watts for the older models. It provides the same amount of light output and operates at significantly lower temperatures—100 degrees Fahrenheit compared to more than 1, 000 degrees Fahrenheit—virtually eliminating the fire hazard.

Renewable energy technologies can provide emergency power. For example, fuel cells can convert the chemical energy of nonpetroleum fuels to electricity with little or no pollution and with greater efficiency than heat engines and can provide this power continuously and reliably. Solar heating and cooling technologies also reduce a building's reliance on the power grid, reducing the impact of business interruptions during power outages. Grid-independent solar electric cells are already widely used to support traffic lighting, communications and other critical services during natural disasters.

Links to Financing

Interest in providing consumer financing for energy efficiency improvements began back in the 1970's during the energy crises. When energy efficiency financing was first introduced in the early 1980's, it exhibited very little success. Most of the literature reviewed attributes this not to lack of interested, but rather to several other factors, or barriers. According to a recent guide for lenders on energy efficiency financing by the Alliance to Save Energy, these barriers include:

- the lack of marketing the product to consumers
- the absence of a clear and concise definition of energy efficiency, which led to the perception of increased risk to the lender
- the reality that the popular "two-percent stretch" was not enough of an incentive to attract consumers
- the lack of consistent energy rating systems, or trained Home Energy Raters and installers
- lack of a secondary market for energy efficiency mortgages

Since about 1992, there has been another push in the marketplace for energy efficiency financing programs. More market actors are getting involved, and lenders and consumers alike are beginning to see the value of owning a more efficient home, however participation in such programs continues to be low. The following sections describe the latest types of energy efficiency financing that currently exist in the market place, as well as the barriers that continue to impede the programs.

Types of Loans

Energy Efficient Mortgages (EEMs) provide mortgage insurance to purchase or refinance a principal residence and incorporate the cost of energy efficient improvements into the mortgage. All buyers who qualify for a home loan qualify for the EEM. The EEM is intended to give the buyer additional benefits on top of their usual mortgage deal. The lender will use the energy-efficiency of the house, as determined by a HERS rating, to determine what these benefits will be. Energy Efficient Mortgages can be done on most homes, and availability is not limited by location, home price or utility company.

All energy efficiency loans currently available require a Home Energy Rating (HERS). The U.S. Department of Energy recommended Home Energy Ratings contain a numerical score from 1 to 100, a one to five star-plus rating, and the estimated energy costs. Higher scores indicate greater efficiency. Cost-effective upgrades are those which will save more money through energy savings than they cost to install. A HERS rating usually costs between $100 and $300, and can be paid by the buyer, seller, lender, or real estate agent. Sometimes the cost of the rating may be financed as part of the mortgage.

Today, homeowners and home buyers generally have two types of loan options that are available to them to improve their homes—either through federally-sponsored programs, or through private loaning institutions (Alliance to Save Energy Lender's Guide).

Federal Programs

Currently, the federal government sponsors three types of loans geared toward energy efficiency, and are described briefly as follows.

Federal Housing Administration (FHA) EEMs. Available in all 50 states, this type of mortgage covers energy efficiency upgrades in new and retrofit situations. The key components of this FHA-insured loan are:

1) Maximum loans limits may be exceeded by the amount of the cost-effective energy improvements
2) Borrower automatically qualifies for the higher loan amount if improvements are determined to be cost effective by an energy rating or energy consultant
3) Improvements up to $4,000 or five percent of the property value (not to exceed $8,000) may be financed
4) No additional cash down payment is required
5) No new appraisal is required.

203 (k) FHA Home Rehabilitation Loans. Most mortgage lenders require that improvements to a home be made before a permanent mortgage is issued. This program, however, enables a home buyer or investor to obtain a single loan to finance both property acquisition and complete major improvements after the time of loan closing. The maximum mortgage amount is limited to the projected property value plus the added cost of the energy improvements. Key components of this program include:

1) Loan principal amount may exceed the locale-based statutory loan limits by the amount of the cost-effective energy improvements
2) Eligible improvements: added insulation, more efficient doors and windows, and high-efficiency heating, ventilating and air conditioning systems
3) Total cost of home improvements, including energy conservation measures, must exceed $5,000.

Veterans Affairs EEMs. This mortgage is available to qualified military personnel, reservists and veterans in all 50 states for energy improvements when purchasing an existing home. The loan requirements are similar to the FHA EEM program, and also include:

1) Borrowers may add up to $3,000 to a loan based solely on documented costs, or up to $6,000 if the increased mortgage payment is offset by a projected equivalent reduction in utility costs determined by a qualified HERS rater.

2) Eligible improvements include conventional or solar heating/cooling systems, water heaters, insulation and weather stripping, thermostats, and storm doors and windows.

Non-Federal Energy Efficiency Loan Programs

Fannie Mae and Freddie Mac. Guidelines for Fannie Mae and Freddie Mac energy efficient mortgages allow lenders to increase qualifying ratios two percent on the debt-to-income ratio requirements for energy efficiency financing. This is a common loan and is referred to the "two percent stretch mortgage." A debt-to-income ratio "stretch" means that a larger percentage of the borrower's monthly income can be applied to the monthly mortgage payment. This loan only benefits borrowers who have reached the limit of their income ratios. This mortgage is also more commonly used in new construction where efficiency improvement levels are easiest to measure.

New homes that meet the 1992 Model Energy Code automatically qualify for these loans, and existing homes qualify after having a HERS rater determine the level of efficiency. Key components of these programs include:

- Borrower is eligible for approximately 97% financing, is able to finance closing costs and the up front mortgage insurance premium into the mortgage, and will also be responsible for paying an annual premium.
- Eligible properties are one-to-two unit existing and new construction.
- The cost of the energy efficient improvements that may be eligible for financing into the mortgage is the greater of 5% percent of the property's value (not to exceed $8,000) or $4,000.
- To be eligible for inclusion in the mortgage, the energy efficient improvements must be cost effective, meaning that the total cost of the improvements is less than the total present value of the energy saved over the useful life of the energy improvement.
- The cost of the energy improvements and estimate of the energy savings must be determined by a home energy rating system (HERS) or energy consultant. Up to $200 of the cost of the energy inspection report may be included in the mortgage.

In applying for an EEM, the home owner or home buyer can either finance the cost of the energy efficiency improvements into the purchase cost of the home (tacking it onto the home purchase mortgage) if it is a new home purchase, or, they can apply for an EEM to upgrade an existing home, refinancing their existing mortgage to include the energy efficiency improvements.

Primary Lender Programs. Most lenders who offer EEMs structure their programs like the Fannie Mae/Freddie Mac program, that is by using the “stretch loan.” There are also some lenders who will loan more than the amount permitted so that more borrowers will qualify for super-efficient homes. In California, for example, some lenders will qualify borrowers for a 10% larger loan for PG&E’s “super-efficient” homes. Lenders are also beginning to include their own incentives for consumers to take advantage of these loans (e.g., waived appraisal fees, special interest rates).

Utility Sponsored EEM Programs. There are some utilities who have initiated their own financing programs, partnering with lenders, to help consumers purchase new high-efficiency homes. Utilities have programs that are focused on new construction as a way of maintaining or even increasing market share during the transition into the competitive marketplace, as well as programs whereby the utility partners with lenders to provide unsecured loans to home owners for energy efficiency improvements, and require minimal credit checks.

Barriers to Financing Linkages

According to a case study report by the National Renewable Energy Laboratory entitled “Case Studies of Energy Efficiency Financing in the Original Five Pilot States, 1993–1996,” (Farhar et al 1997), there are several barriers to the institutionalization of linking energy efficiency financing with home energy rating systems because they require significant changes in the roles and responsibilities of real estate transactions and financing communities. In addition, the perceptions of program barriers vary to some extent by role, institutional type, and specific organizational location.

Lender hesitance: Lenders in Virginia do not offer the FHA EEMs as a regular product in Virginia because, according to a HUD official, their lending and underwriting staff members do not understand the program. It is the perception of HUD that Virginia lenders were not actively marketing the program to consumers, although they did respond to specific requests for an EEM. The HUD official reported that lenders believed EEMs were more complicated to process than other loans, and indeed, lenders believed that they were more complicated than they actually are (perception barrier). In addition, HUD staff believed that loan providers were not providing accurate information regarding EEMs, and that loan officers themselves remained inadequately trained and therefore could not provide the necessary information to borrowers. These barriers are from the perspective of HUD.

Risk aversion: HUD staff believed that VA lenders were not interested in part because of their concern about the marketability of EEMs in the secondary mortgage markets. The lenders’ concern, according to HUD, was the although Fannie Mae might buy the loans, the banks’ own particular investors would not. The energy-improved properties were often being financed at very high loan-to-value ratios, which made them appear to be riskier investments than others available. Another reason for lender hesitance noted by HUD was that lenders did not need to know about these products to make money. When the market for refinancing slowed down in 1995, lenders then became more active in processing 203k loans. Because national lenders set policies that affect lending nationwide, their posture toward energy efficiency financing would affect lending in VA as well as in other pilot and nonpilot states.

Processing difficulties: Several VA lenders reported to HUD that they had some problems with customers in connection with EEMs: energy improvements were installed improperly; and the installation process exceeded the escrow period permitted.

Lack of incentives for HUD staff: There are numerical goals set for each HUD Field Office in terms of quotas for the number of loans processed by each type. However, at least in VA, there have not been any quotas set for EEMs, unlike 203(k) loans. As such, HUD representatives place higher priority on 203(k) loans.

Uninformed real estate professionals: HUD staff perceive that real estate professionals are not very informed about the availability of EEMs and how to use them in marketing real estate.

Lack of sufficient consumer information: The VA HUD official believed that most consumers in VA would call Virginia Power if they were interested in energy-efficiency programs. Virginia Power could make a referral to a lender offering EEMs or to a HERS provider.

Barriers from HERS Provider Perspective

In Virginia, there is only one organization, V-HERO, that conducts home energy ratings. The following barriers stem from their perspective, and were obtained from the same report as above.

Misperceptions about the market for EEMs

- lack of adequate funding for consumer marketing
- misperceptions and misunderstanding of the market on the part of allied industries; e.g., consumers are not motivated to participate in energy-efficiency programs, energy-efficiency improvements are too costly, and that processes involved are complex and slow.

Problems with routine practices in real estate transactions

- lender and real estate forms commonly used do not convert readily to include financing of energy-efficiency products
- mortgage insurance premiums, which increase because of higher amounts borrowed, offset energy cost savings that could be realized by consumers

Other barriers believed to exist for HERS/EEF programs include:

- lack of experience with the effective use of advertising. This prevents rating organizations from using paid advertising to promote customer action and public relations activities to build image.
- Failure to differentiate the rating product from utility audits. Rating organizations may see themselves as competitors of utility companies; customers fail to perceive the differences between ratings and utility audits, except for the costs (rating are more expensive).

Energy Efficiency Financing Market Barriers

According to an article entitled, “Making the American Dream More Affordable Through Energy Efficiency Financing,” (Verdict 1996), there are several market barriers to these energy efficiency financing programs, and include the following which are not exclusive of those mentioned above:

- perceived risk—the secondary mortgage lenders have little enthusiasm for energy efficiency loans because of the increased potential for loss if the loan defaults
- Non-uniform energy ratings—mortgage lenders demand uniformity when packaging loans for resale. Unfortunately, there are numerous rating approaches, including performance and certified ratings that contribute to the lenders’ aversion.
- Small profit potential—lenders do not view energy efficiency financing as a profitable lending area due to overall weak consumer demand
- Increased paperwork—energy efficiency documentation creates additional paperwork and can slow a loan process already overburdened
- Consumer awareness and incentives—lenders seldom advertise energy-efficient mortgages. Therefore, consumers are generally unaware of existing energy-efficient mortgage programs such as the two-percent stretch loan available nationwide through Fannie Mae and Freddie Mac.
- Financial incentives—without an EEEM, purchasers can borrow no more money for a very efficient house than for one meeting minimum code requirements, although one may cost hundreds of dollars more. Additionally, utility DSM rebates for more efficient heating and cooling equipment, insulation, lighting, and appliance are nearly gone.

Opportunities to Improve Measure Installation Effectiveness Through Financing Linkages

According to one author, significant marketplace changes and removal of institutional barriers are causing renewed interest and guarded optimism about the future of energy efficiency financing (Verdict 1996). Structural marketplace changes impacting the increased viability of energy efficiency financing include:

- new Federal EEM programs
- development of uniform, national home energy rating guidelines
- increased competition in the banking, housing and utility industries
- establishment of new, industry-based, support organization for HERS and EEMs, and
- a shift in the Federal roles of DOE and EPA from one of a regulator to facilitator.

New Federal EEM programs. Following the pilot program, EPAct92, the introduction of a nationally available EEM program was established in 1995. This loan program, available to homeowners, removed two principal barriers: it required no additional cash down payments and provided automatic approval for the cost-effective energy upgrades.

Uniform home energy rating guidelines. One of the main market barriers that existed was that there were no consistent uniform, “technically verifiable” energy rating tools by which to measure the energy efficiency of homes. While there has been some headway with the 1995 Notice of Proposed Rule making for voluntary HERS guidelines, the success of these guidelines is still unknown, as there is some debate over several of the components.

Increased industry competition. With deregulation of both the banking and utility industries, there has been a natural and visible increase in competition among these key EEM market players. Lending institutions who add energy features into their portfolios further increase market differentiation among their competitors. Also, utilities looking to retain or increase their market share, are looking to replace old DSM consumer programs with new innovative services, such as financing programs.

Industry-based organizations that promote EEMs and HERS. As previously discussed, the increased industry competition has sparked renewed interest in EEMs. And, with the now available Federal programs, there have been numerous industry-based groups established, dedicated to removing market barriers, promoting energy financing, helping to create other rating organizations, and promoting energy ratings at national and local levels.

Federal role shifts from regulator to one of market facilitator. Federal agencies seem to have shifted their focus from being regulators in the 1970’s to facilitators in the 1990’s. With the establishment of the Energy Star Homes program, for example, EPA is working to promote efficiency and increase market demand, rather than simply regulate what efficiency guidelines and standards should be.

Role of Market Transformation and PGC-Funded Programs in the Standards Process

Summary of Residential Standards

The 1998 Residential Standards have an effective date of July 1, 1999. These standards cover all low-rise residential occupancies including:

- All single family dwellings of any number of stories (Group R-3)
- All duplex (two-dwelling) buildings of any number of stories (Group R-3)
- All multi-family buildings with three or fewer habitable stories (Groups R-1 and R-2)
- Additions and alterations to all of the above buildings

NOTE: All hotels and motels comply with the nonresidential standards.

To comply with the low-rise Residential Standards, a building must be shown to meet two basic requirements:

- Installation of several *mandatory measures* representing minimum conservation features and devices; and
- Demonstration that the building's predicted annual energy use meets the designated *energy budget* for space heating and cooling, and for water heating.

Mandatory Measures

Minimum ceiling, wall and raised floor insulation levels; minimum HVAC (heating, ventilating and air conditioning) and water heating equipment efficiencies are required features that apply to all low-rise residential buildings even if those features are not sufficient to show that a specific building meets the energy budget. For example, R-13 insulation in wood frame walls is a mandatory measure. However, a building may be designed with R-19 walls in order to meet the energy budget. In that case, the R-19 supersedes the R-13 minimum requirement, and the R-19 must be installed for the building to comply. The same holds true for the other mandatory minimum insulation levels and equipment efficiencies

The following is a list of all technologies covered in the Manual.

- Building Envelope
    - Mandatory Measures
    - Installation of Certified Insulating Material
    - Ceiling Insulation
    - Loose Fill Insulation
    - Wall Insulation
    - Raised Floor Insulation
    - Slab Edge Insulation
    - Insulation in Existing Buildings
    - Fenestration/Exterior Doors
    - Joints and Other Openings
    - Vapor Barrier
    - Special Infiltration Barrier
    - Fireplaces, Decorative Gas
    - Appliances and Gas Logs
- Space Conditioning, Water Heating and Plumbing System Measures
    - Systems and Equipment Certification, Appliance Efficiency Regulations
    - Space Conditioning Sizing
    - Setback Thermostats
    - Heat Pump Controls
    - Water Heater Tank Insulation
    - Pipe Insulation
    - Solar Water Heating
    - Ducts, Plenums and Fans
    - Pool/Spa Equipment
    - Pilot Lights Prohibited
- Lighting
    - Kitchen Lighting
    - Bathroom Lighting
    - Recessed Lighting

Changes for 1998 Residential Standards

Thermal Mass

Thermal mass is no longer required for compliance with prescriptive package D (Package E was eliminated because the only difference between the two was the thermal mass requirement). Homes designed for passive solar can use Package A or computer compliance to account for the benefits of a significant amount of thermal mass.

Water Heating

An R-12 water heater insulation blanket is mandatory for water heaters with an energy factor that is below 0.58. No compliance credit is given for water heater insulation. Compliance with the water heating budget is achieved with a non-recirculating, storage gas water heater, with a 0.53 energy factor.

Fenestration

All manufactured products must have a label with the U-value and Solar Heat Gain Coefficient (SHGC). All references to shading are now in terms of SHGC instead of Shading Coefficient (SC). Only field-fabricated fenestration does not need to be labeled. The term field-fabricated replaces site-built, and refers to products where the frame is made from materials not previously cut or formed with the intention of being used for a fenestration product. Field fabricated does not include site assembled frame components that were manufactured elsewhere with the intention of being assembled on site (such as knocked down products, sunspace kits and curtain walls).

Shading

In prescriptive compliance, shading must be provided by a fenestration product with the required SHGC (e.g., low-e_2), an exterior shading device or an overhang. Interior shading devices cannot be used to show compliance with prescriptive SHGC requirements. SHGC (instead of SC) are fixed at 0.68 for draperies, 0.47 for blinds and 0.47 for roller shades until December 31, 2001. Beginning January 1, 2002, roller shades cannot be used for compliance. These are the only acceptable values for interior shading devices.

Ducts

All pressure-sensitive tapes, mastics, aerosol sealants or other closure systems must meet applicable UL 181A and B requirements Drawbands Used with Flexible Duct shall:

- be either stainless-steel worm-drive hose clamps or UV-resistant nylon duct ties.
- have a minimum tensile strength rating of 150 pounds.
- be tightened as recommended by the manufacturer with an adjustable tensioning tool.

Credit for tight ducts, verified through diagnostic testing, is allowed with a computer compliance approach.

Lighting

The general lighting in kitchens must provide sufficient light for basic kitchen tasks and provide a uniform pattern of illumination. A light in a corner of the kitchen, whether efficient or not, will no longer meet the requirement. The control for the general lighting in kitchens must be on a readily accessible switch at one of the entrances to the kitchen. This eliminates the need for determining what is the most accessible switch. Readily accessible means that it can be reached quickly without removing obstacles. The bathroom lighting requirements were changed to require a high efficacy light source in each room with a shower or bathtub (no reference to water closet). An alternative to the bathroom lighting is to install *both* of the following:

- A high efficacy lamp in a utility room, laundry room or garage; and
- All luminaires permanently mounted to the exterior of the residence for outdoor lighting must either have high efficacy lamps or be equipped with a motion sensor.

Raised Floor Insulation

R-8 insulation for concrete raised floor (e.g., apartments with underground parking) is no longer a mandatory requirement. Prescriptive Package D requires R-8 in climate zones 1, 2, 11, 13, 14 and 16, R-4 is required in zones 12 and 15, no concrete raised floor insulation is required in zones 3–10.

Space Conditioning

Prescriptive compliance with Package D can be achieved with any type of space heating, such as a wall furnace or space cooling system that complies with applicable appliance efficiency requirements. A setback thermostat is required.

Alterations

When space conditioning or water heating equipment is changed, it is limited to natural gas, liquefied petroleum gas or the existing fuel type. This prevents change outs to less efficient fuel sources. A new computer compliance provision for existing-plus-alteration allows trade-offs in alterations. This provision is primarily for an applicant who: (1) cannot or does not want to meet the 0.75 U-value for windows, or (2) wants to change from gas or LP to electric heating or water heating.

High-rise residential and hotel/motel occupancies were covered under the 1978 *First Generation* Residential Standards until July 1992, when they come under the Nonresidential Standards. A relatively small set of revisions constituted the changes for the 1995 standards focusing on compliance and implementation issues rather than developing new standards. The 1998 revisions again focused on compliance and implementation issues.

Summary of Nonresidential Standards

The codes and standards apply to the following nonresidential applications:

- Unconditioned Space
- Newly Conditioned Space

- New Construction in Existing Buildings
- Alterations to Occupied Spaces
- Additions
- New Buildings
  - Speculative, Known Occupancy
  - Speculative, Unknown Occupancy
  - Mixed Use
  - Semi-Conditioned
  - Change of Occupancy
- Repair

There are two basic options for demonstrating that a building meets the requirements of the *Standards:* the prescriptive approach and the performance approach. With either approach, certain mandatory measures always apply. The *Standards* cover the three major components of a nonresidential building: the building envelope, the mechanical systems, and the lighting systems. A minor energy user, water heating, is also covered. Each component is typically the responsibility of a different design professional. The envelope is designed by an architect, the mechanical systems by a mechanical engineer, and the lighting systems by an electrical engineer. Each of the three components may be shown to comply independently under the prescriptive approach. Under the performance approach, *Standards* compliance may be shown for the envelope only, the envelope and mechanical systems, or for all three components.

Alternatively, the building (all three components) may be shown to comply as a whole under the performance approach when the permit application includes all three components. The prescriptive approach is the simpler way to comply with the *Standard*s. Each of the three building components complies separately from the others. The compliance procedures and documentation are also separate for the three. The prescriptive approach for each component requires that the proposed system design be shown to meet specific energy efficiency criteria specified by the *Standard*s. If the design fails to meet even one of the requirements, then the component does not comply with the *Standard*s.

The following is a list of all technologies covered in the Manual.

- Envelope
  - Insulation R-value
  - Overall Assembly U-value
  - Wood Frame U-values
  - Metal Frame U-values
  - Masonry U-values
  - Heat Capacity
  - Fenestration U-values
  - Solar Heat Gain Coefficient
  - Relative Solar Heat Gain

- Envelope Design Procedures
    - Mandatory Measures
    - Doors, Windows and Skylights
    - Joints and Openings
    - Insulation Materials
    - Demising Walls
    - Exterior Roofs and Ceilings
    - Exterior Walls
    - Demising Walls
    - Exterior Floors and Soffits
    - Windows
    - Skylights
    - Exterior Doors
    - Overall Heat Loss
    - Overall Heat Gain
    - Modeling Envelope Components
    - Alterations
- Mechanical
    - Types of Air
    - Air Deliver System
    - Attics and Return Plenums
    - Zone Reheat, Recool and Air Mixing
    - Economizers
    - Unusual Sources of Contaminants
    - Demand Control Ventilation
    - Intermittently Occupied Spaces
- Mechanical Design Procedures
    - Pilot Lights
    - Outdoor Ventilation
    - Natural Ventilation
    - Mechanical Ventilation
    - Ventilation System Operation and Controls
    - Required Controls for Space Conditioning Systems
    - Requirements for Pipe Insulation
    - Requirements for Ducts and Plenums
    - Service Water Systems
    - Pool/Spa Heating Systems
    - Sizing/Equipment Selection
    - Load Calculations
    - Fan Power Consumption
    - Space Conditioning Zone Controls
    - VAV Zone Controls
    - Economizers

- Supply-Air Temperature Reset Control
    - Electric Resistance Heating
    - Service Water Heating
- Lighting Systems
    - Lighting Trade-Offs
    - Lighting Controls 5–9
- Lighting Design Procedures
    - Mandatory Measures
    - Area Controls
    - Bi-Level Switching
    - Daylit Areas
    - Shut-Off Controls
    - Display Lighting
    - Exterior Lights
    - Tandem Wiring
    - Certified Automatic Lighting Control Devices
    - Certified Ballasts and Luminaires
    - High Rise Residential
    - Living Quarters & Hotel/Motel Guest Rooms

Changes for 1998 Nonresidential Standards

Structural

Beginning with the 1992 *Standards,* there is no longer a grandfather clause that allowed compliance for a building that began with a certain standard, to continue under that standard until the building was completely constructed. Also there was no reference to past standards on a permit application. These *Standards* apply to all nonresidential as well as to all high-rise residential, hotels, and motels since these occupancies more closely resemble nonresidential than residential in terms of their mechanical systems and energy use patterns.

The *Standards* apply only to the systems and portion of the building for which a building permit is sought. This simplifies both compliance and enforcement, virtually eliminating the need to consider other systems or parts of the building in the compliance process. The prescriptive *Standards* do not permit energy efficiency trade-offs between systems. Each of the three sections, envelope, mechanical and lighting, stand alone.

The performance approach establishes the energy budget on a custom basis for each building. The custom budget is automatically generated by an approved computer program that is used to estimate the building's annual energy use.

The performance approach limits the range of options available for trade-off (items that can change between standard and proposed cases). Trade-offs are only allowed for those features specifically included in the building permit application, as well as for all existing conditions and systems that are to remain and are subject to the current *Standards* (see Section 6.1). Systems that will be installed under a future permit application are not available for trade-off.

Technical
The 1998 Energy Efficiency Standards became effective July 1, 1999.

A. Scope and Application

- A new category of "semi-conditioned" building will comply with lighting requirements.
- A semi-conditioned building is a nonresidential building with conditioning that currently does not meet the definition of a directly conditioned—less than 5 Btu/hr/ft2 of cooling, less than 10 Btu/hr/ft2 of heating, evaporative cooling, wood heat, conditioned for a process environment below 55 or above 90°F.
- The definition of directly conditioned is changed to exclude from compliance spaces that are not maintained outside the comfort range (55–90°F), that is the temperature floats in and out of the comfort range, but are incapable of operating and maintaining the space within the comfort range.
- Definitions of mechanical cooling and mechanical heating remove the phrase "for the purpose of maintaining human comfort."

B. Envelope

- The heat gain and heat loss equations were updated for accuracy and the heat gain equation now considers the effects of opaque surfaces where it formerly considered only fenestration.
- Prescriptive high-rise residential requirements now include insulation for concrete raised floors (e.g., apartments with underground parking) to match low-rise requirements. R-4 is required in climate zones 12 and 15, and R-8 in climate zones 1, 2, 11, 13, 14 and 16.
- When a portion of an entire building's fenestration is repaired or replaced, or 50 square feet or less of glass is added, compliance with the solar heat gain coefficient requirements of Section 143 is not required.
- All manufactured fenestration products must have a label with the U-value and Solar Heat Gain Coefficient (SHGC). These values can be NFRC or default values. The default values are found in the Standards, Section 116.
- Glazed wall systems and overhead glazing do not need to be labeled. These products must still determine a U-value and SHGC using NFRC or default values.
- Field-fabricated fenestration does not need to be labeled. These products will use the default values. This term replaces site-built, and applies to products whose frame is made at the construction site of standard dimensional lumber or other materials that were not previously cut, or otherwise formed with the specific intention of being used to fabricate a fenestration product or exterior door. Field fabricated

does not include site assembled frame components that were manufactured elsewhere with the intention of being assembled on site (such as knocked down products, sunspace kits and curtain walls).

C. Mechanical

- All pressure-sensitive tapes, mastics, aerosol sealants or other duct closure systems must meet applicable UL 181 requirements
- Drawbands used with flexible duct shall:
    - be either stainless-steel worm-drive hose clamps or UV-resistant nylon duct ties.
    - have a minimum tensile strength rating of 150 pounds.
    - be tightened as recommended by the manufacturer with an adjustable tensioning tool.

- Prescriptive fan power limitations for variable air volume systems are changed to reflect improvements in technology and system efficiency. Individual VAV fans with motors over 25 HP (adjusted for air filtering systems) must meet one of the following:
    - The fan motor shall be driven by a mechanical or electrical variable speed drive.
    - The fan shall be a vane-axial fan with variable pitch blades.
    - The fan motor shall include controls that limit the fan motor demand to no more than
- 30% of the total design wattage at 50% of design air volume when static pressure set point equals 1/3 of the total design static pressure, based on certified manufacturer's test data.
- A new exception to prescriptive economizer requirements is provided for spaces or rooms with a dedicated space conditioning system where the use of outdoor air is detrimental to equipment or materials. Possible examples include computer room, telecommunications, and other equipment rooms.

D. Lighting

- Reduced control credits for lumen maintenance (from 10 to 5%) and for combined occupancy sensor and lumen maintenance (from 37 to 25%).
- 22 new categories of building uses are added to the Area Category Method.
- Lighting levels in all compliance approaches are reduced to account for substituting T-8 lamps with electronic ballasts for T-12 lamps with magnetic ballasts. Reductions are based on the prevalence of fluorescent lighting in the building model.

Summary of Energy Commission's Standards Support Activities

The CEC contributes to the standards implementation process through the following technical assistance and implementation support mechanisms, all of which can be accessed on the California Energy Commission’s website (http://www.energy.ca.gov.title24/index.html):

- **Preparation of residential and nonresidential manuals:** Section 25402.1 of the Public Resources Code requires that the California Energy Commission make available compliance materials, including an energy conservation manual. The *Nonresidential Manual for Compliance with the 1998 Energy Efficiency Standards* (P400-98-005) *(Manua*l) is provided to meet the requirement of this section. *The Manual* includes compliance method descriptions, calculation procedures, technical data, examples, and sample compliance forms for meeting the *Standards* for Nonresidential Buildings, High-Rise Residential Buildings, and Hotels/Motels.
- **Development of an alternative calculation method and associated software:** The Nonresidential Alternative Calculation Method (ACM) Approval Manual is intended strictly for those persons who want to design a calculation computer program for use with the energy standards. Before such programs may be used to demonstrate compliance with the standards, they must be approved by the Energy Commission through the process described in the Manual.
- **Compilation of a list of approved computer programs for determining building compliance with codes:** The following energy analysis computer programs includes all Alternative Calculation Methods approved by the California Energy Commission for the nonresidential sector. These programs are in accordance with the California Code of Regulations Title 24, Part 1, Article 1, Section 10-109 (1998 Standards):
    - EnergyPro, Version 2.0
    - Perform 98
- **Maintenance of an information hotline:** The Energy Hotline is run by the California Energy Commission's Efficiency Division, and provides callers with comprehensive and timely technical information on how to comply with the Title 24 Building Energy Efficiency Standards and information on Appliances certified for sale in California. It is used daily by hundreds of utility, building and energy professionals, and responds to technical questions with a variety of consumer services, including:
    - Toll-free phone number
    - Direct access to trained energy specialists
    - Technical information and detailed personal responses
- **Publication of a regular newsletter, *Blueprint*, for building professionals:** Blueprint is a newsletter of the California Energy Commission and its Energy Efficiency Division's Efficiency Standards Office. It focuses on California's Title 24 Building Energy Efficiency Standards.
- **Maintenance of a question and answer forum, *Energy DoctorÔ*, for consumers:** The *Energy DoctorÔ* is a service of the Efficiency Technology Office of California Energy Commission's Energy Efficiency Division. The Doctor answers questions relating to energy efficiency of consumers' home and appliances. Responses are those of the staff of the Energy Efficiency Division and not the entire Commission, its management or commissioners.

- **Publication of the *Home Energy Guide*, which provides energy efficiency tips for homeowners:** The down-loadable Home Energy Guide is a manual for homeowners that was created by the California Energy Commission as a guide to the energy-saving features in new California homes.
- **Publication of *Six Steps to an Energy Efficient Addition*, which provides guidance to homeowners for completing energy compliance forms:** This step-by-step guide aimed at helping homeowners correctly fill out detailed forms. It is currently under construction at the CEC website.
- **Certification of home energy rating services:** The California Energy Commission is required by Public Resources Code Section 25942 to establish regulations for a Home Energy Rating System (HERS) Program to certify home energy rating services in California. These services are to also include field verification and diagnostic testing available through Commission-certified providers and their raters when duct efficiency and envelope leakage measures are installed for complying with the new 1998 building efficiency standards (effective July 1, 1999).
- **Establishment of protocols for "Quality Homes" techniques to verify quality residential construction with diagnostic tools**: This online resource provides techniques to verify quality construction with diagnostic tools, and includes
    - protocols for energy efficient residential building envelopes: Specifications and techniques to improve the installation of energy features such as insulation, windows, mechanical ventilation, and caulking and sealing, as well as design issues that affect the installation of HVAC systems and insulation
    - procedures for HVAC system design and installation: Specifications and techniques to improve the design, fabrication, installation and testing of HVAC systems
    - quality construction assessment project: Evaluates new California homes to determine the installation quality of their energy features
- **Hosting of automated email groups regarding efficiency standards, public benefits programs, and home energy rating systems:** Another online resource on the CEC website in which the Commission hosts a number of discussion groups covering various topics.
- **Compilation of a roster of certified energy plan examiners for residential and nonresidential buildings:** This online roster contains the names of individuals who have satisfactorily completed a voluntary certification program in which they have demonstrated a broad understanding of how to prepare and review building plans. The CEC recommends that building officials, industry professionals, contractors and building owners use this roster when selecting a qualified individual to prepare or review energy compliance documentation.
- **Publication of a directory of certified equipment for residential space conditioning and water heating:** This is an online directory that allows users to access listings of appliances which exceed California and Federal appliance efficiency standards.

The CEC also offers training courses for energy consultants, building officials, HERS raters, contractors and other building industry market actors

In addition to CEC-sponsored support activities, a number of other agencies and market actors play a role in the standards implementation process. Local government building officials play a primary role in enforcing the standards through plan checks and field inspections. BII, various utility programs, and the CHEERS program all engage in training energy consultants, building officials, HERS raters, contractors and other building industry market actors. Various utility programs also include compliance checking, diagnostic testing, HERS rating, and builder promotion assistance to market homes that meet and exceed the standards.

In addition to ongoing standards implementation activities, the CEC manages a standards development process that produces revisions to the standards every three years. Activities associated with this process are cyclical in nature. A partial listing of CEC activities associated with the process includes

- Hosting automated email groups regarding efficiency standards, public benefits programs, and home energy rating systems
- Sponsorship of public workshops and hearings to address building energy research findings, compliance option development, public domain and approved calculation methods, HERS rating program regulations, and standards updates
- Research and development related to building energy problems (e.g., the PIER program) and possible solutions to those problems through, among other things, standards changes

Standards Enforcement Process

Enforcement is primarily the purview of local planning departments. The Warren-Alquist Act, chapter 5, section 25402.1, subdivision (g), states that "[n]o building permit for any residential or nonresidential building shall be issued by a local building department, unless a review by the building department of the plans for the proposed residential or nonresidential building contains detailed energy system specifications and confirms that the building satisfies the minimum standards established pursuant to subdivision (a) or (b) of Section 25402 and this section applicable to the building."

RER (1999) describes the three options for demonstrating compliance. The prescriptive method is achieved by installing components which have performance specifications equal to or better than the values given by one of several "packages" of specifications from the standards. Requirements are included for envelope, mechanical, and lighting components of the building. No trade-offs are allowed. The computer analysis performance method establishes an "energy budget" for the building configuration with prescriptive measures relevant tot he climate zone of interest. Compliance is achieved by keeping the simulated energy use less than the baseline energy budget. The point system performance method assigns points to various types of conservation measures. Positive points are assigned to features or performance levels that exceed levels used to develop the standard energy budget while negative points are assigned for measures below standard levels. Compliance is obtained with an overall score of 0 or greater.

Standards Development Process

According to RER (1999), the CEC administers changes to the standards in three-year cycles. Interested parties may submit proposals for changes to the standards to the CEC at any time. Proposals are reviewed by CEC staff, discussed in public hearings, and voted on by commissioners. Typically, hearings are attended by interested parties in the building industry such as manufactures and professional associations for builders, contractors, and Title 24 consultants.

Program Planning Process

The program planning process the utilities have followed for the 1999 and 2000 program years is detailed in the CBEE Advice Filing 1-G/1-E, Recommendations of the *CBEE on 1999 Energy Efficiency Programs and Budgets, Institutional and Transition Issues, and Adopted Policy Rules*, date October 16, 1998. The CBEE highlights the following significant objectives and principles underlying its recommendations in this advice filing:

1. Primary reliance on the Commission's adopted policy rules for energy efficiency activities, with limited modifications appropriate for the period of interim administration.
2. Adoption of new program definitions to facilitate the design and implementation of a coordinated set of PGC-funded activities that is targeted toward the transformation of individual markets for energy-efficient products and services within each program administrative area.
3. Continued movement toward uniform, statewide program designs that share common elements across administrators or consolidate activities within a single administrator.
4. Continued transfer of program implementation activities to private market participants, including continued and expanded reliance on targeted solicitations, such as the Standard Performance Contract and Third-Party Initiative intervention strategies.
5. Continued alignment of PGC-funded activities with considerations based on customer class contributions to electric PGC and gas DSM funds.
6. Uniform performance incentives for administrators with common designs capped at lower total awards and with a limited number of activity-based, performance milestones that are linked to pursuit of the Commission's market transformation objectives.
7. Continued commitment to important market assessment and evaluation (MA&E) activities, and to a process to plan and prioritize the activities, with total MA&E funding at levels below those of pre-1998 years.

In PY98, the electric utilities, as Interim Administrators for PGC energy efficiency funds, took important steps in program re-design and new program offerings in pursuit of the Commission's objectives, which the Commission later formally adopted as policy rules in decision D.98-04-063.

1. The utilities introduced and shifted a significant share of PGC funds away from traditional utility-led rebate programs to a new program, called the Standard Performance Contract Program, which directly

addresses the Commission's adopted policy rule expressing a preference for activities that will "encourage direction interaction and negotiation between private market participants (including energy efficiency service providers) and customers, building lasting relationships that will extend into the future," and which also contained strong consumer protections. (Adopted Policy Rule II-6, and IV-7.)

2. Along similar lines, the utilities introduced a new approach for developing and funding PGC energy efficiency programs, called the Third-Party Initiative Program, through which market participants could obtain funding to operate qualifying energy efficiency programs of their own (rather than of the utilities') design.
3. The utilities developed and expanded existing programs that collectively were grouped under a new supra-category, called Integrated and Upstream Market Transformation Programs, which addresses another Commission preference for activities that will "transform the 'upstream' market (e.g., manufacturers, distributors, retailers, and builders) so that energy-efficient products and services are made available, promoted, and advertised by private market participants." (Adopted Policy Rule II-6.)
4. In aggregate, funding for residential and non-residential programs closely reflected the contributions of these customer classes, again reflecting another Commission preference for programs that "align the benefits of PGC programs with the customers providing PGC funds." (Adopted Policy Rule II-6.)
5. Overall performance incentive award levels for the utilities were reduced from previous years, with a corresponding elimination of the linkage between the size of incentive payments and the outcome of sophisticated (and often disputed) measurement and evaluation studies, and an increase in activity-based performance milestones, all consistent with the directions provided in the Adopted policy rules for Compensation and Performance Incentives for Program Administrators.

The CBEE's PY99 planning process consisted of three overlapping phases: (1) an independent assessment of energy efficiency programs with respect to the Commission's energy efficiency policy objectives, conducted by Robert Mowris and Associates (RMA) and Alternative Energy Systems Consulting, Inc. (AESC); (2) CBEE meetings at which background memos prepared by the CBEE's technical services consultants (TSC) on priority issues for the advice filing were discussed; and (3) CBEE meetings and public workshops at which drafts of this filing were discussed.

From this process, the CBEE developed a set of program recommendations based on eight over-arching program design and implementation principles:

1. Continue movement toward uniform statewide program designs and implementation
2. Continue transfer of program implementation away from administrators
3. Rely on competitive processes when outsourcing activities
4. Continue third party initiatives, defer a second general solicitation, and use targeted solicitations
5. Coordinate program activities with regional and national entities, where appropriate

6. Support commercialization of emerging technologies
7. Seek broad input from customers on the design of programs
8. Ensure program offerings are available to under-served communities and customer groups

The CBEE recommendations also involved a new set of program definitions. The program definitions are designed around three program administrative areas: residential, nonresidential, and new construction. Within each program administrative area, multiple individual markets can be identified. These markets are distinguishable from one another by the unique nexus of: (1) end uses and end-use technologies; (2) market participants involved in their specification, purchase, installation, or servicing; and (3) the market events, which encompass a particular grouping of transactions or decisions. The market barriers currently inhibiting or preventing customers from adopting cost-effective energy-efficient products and services derive uniquely from this nexus of factors. The CBEE maintains that, for the purpose of transforming markets, it is this nexus of market features or characteristics that constitutes a distinct market for an energy-efficient product or service. That is, the CBEE takes it that the goal of PGC-funded energy efficiency activities is: (1) to understand how these market features or characteristics collectively lead to under-investment in cost-effective energy efficiency products and services; and (2) to design and implement a coordinated set of intervention strategies that overcome or reduce the underlying market barriers (see policy rule IV-5).The CBEE’s recommendation represents a departure from the previous system of DSM program definitions. The previous system organized ratepayer-funded DSM energy efficiency activities around customer classes (e.g., residential, commercial, industrial, and agricultural) and specific intervention strategies (e.g., customer-specific information, financial incentives, non-customer specific information, etc.).

Expected Influence of Program Elements on Codes Process

The following tables summarize key CBEE programs and program elements expected to have an influence, either direct or indirect, on the code process. The assessment of expected influence is based on a review of PG&E's 1999 Advice Filing. We elected to focus on 1999 because the program changes between 1998, 1999, and 2000 are relatively minor and because 1999 was the first advice filing following CBEE's October 16, 1998 Advice Letter, making it a reasonable representative of the planning efforts in other years since the shift toward market transformation.

We chose to focus on PG&E programs because PG&E programs are, for the most part, representative of the program plans for both PG&E and SCE in PY1999 and PY2000. The advice filings from the two largest utilities show abundant evidence of close collaboration and a distinct shift toward statewide programs. SDG&E program designs are generally consistent in design but relatively narrower in the scope of their activities. SCG program designs are scanty, inconsistent with CBEE's advice letter format, and apparently poorly coordinated with SCE. As an example, SCG promotes Energy Advantage as a new home label along with Energy Star.

Influence can take a number of forms, including commercialization of an emerging technology, developing widespread acceptance of a technology or practice that is a candidate for coverage in the codes, educating practitioners and code enforcement officials, or otherwise facilitating proper code application and good design practice. The tables include only nine of the fourteen programs called for in the CBEE Advice Letter. The remaining programs were judged to be unrelated to the scope of the Codes and Standards MA&E Project. For similar reasons, individual program elements were excluded if they were judged to be unrelated to the project scope. Excluded programs were Nonresidential Motor Turnover, Nonresidential Process Overhaul, Residential Lighting, Residential Appliances, and Industrial and Agricultural New Construction.

Along with CBEE programs and program elements, the tables show PG&E's proposed program interventions for PY1999. Again, only selected interventions have been included, based on their expected ability to influence the code process. As noted above, the interventions shown are, for the most part, representative of the program plans for both PG&E and SCE in PY1999 and PY2000.

Table 2. Nonresidential Program Area Intervention Strategies Expected to Influence the Code Process

Program	Program Elements	1999 PG&E Intervention Strategy
Large Nonresidential Comprehensive Retrofit	Integrated C&I HVAC and Lighting Comprehensive C&I Lighting Retrofit Energy-efficiency Centers	Pacific Energy Center Design and analysis tools, including Lighting Exchange and Cool Tools Project
Small Nonresidential Comprehensive Retrofit	Integrated C&I HVAC and Lighting Comprehensive C&I Lighting Retrofit Energy-efficiency Centers	Pacific Energy Center Design and analysis tools, including Lighting Exchange, Cool Tools Project, Daylighting Initiative, Natural Cooling, and Commissioning and Performance Evaluation Tools
Nonresidential HVAC Turnover	High-efficiency Equipment Sizing, Controls, and O&M	Design and analysis tools
Commercial Remodeling / Renovation	High-efficiency (Lighting) Equipment High-efficiency Design	Pacific Energy Center Design and analysis tools, including Daylighting Initiative

Table 3. Residential Program Area Intervention Strategies Expected to Influence the Code Process

Program	Program Elements	1999 PG&E Intervention Strategy
Heating and Cooling	Efficient Residential Equipment Information and Education Improved HVAC Sizing and Installation Practices Linked HVAC Financial Incentives Regional and National Initiatives	Targeted information to HVAC market actors Energy Star brand promotion to consumers Training, certification and/or inspection for HVAC market actors Technical assistance and sales tools Regional/national strategies for HVAC
Retrofit and Renovation	Promotion and Facilitation of Comprehensive, Discretionary Retrofit Service Facilitation of Efficiency Retrofit at Time of Sale or Renovation Energy Efficiency Centers	Targeted information to consumers planning home purchase, sale, renovation Third party contract for institutionalization of HERS, EEMs Third party contract to work with home improvement centers Stockton training center contractor training Building official training on codes and standards Third party contract with California Window Initiative

Table 4. New Construction Program Area Intervention Strategies Expected to Influence the Code Process

Program	Program Elements	1999 PG&E Intervention Strategy
Residential New Construction	Targeted Consumer Promotion and Information Infrastructure and Product Development Integrated New Home Product Capability Development Market Leader Incentives	Targeted information to consumers in market for new home Promotion of Energy Star Homes label Incentives to third party builder allies CHEERS Energy Star builder sales agent training and tool Training and technical assistance to builders and HVAC subcontractors Builder resource guide
Commercial New Construction	Large Comprehensive Small Comprehensive Prescriptive Energy-efficiency Center	Savings by Design technical and design assistance Targeted information and design incentives Design and analysis tools, including Cool Tools Project and Commissioning and Performance Evaluation Tools
Codes and Standards	New Construction Codes and Standards Support Local Government Initiatives	Code training and public education Develop voluntary design guidelines that exceed current requirements Information, assistance, incentives during local government planning and development process Links to third party financing for building retrofits

Opportunities to Use Standards to Meet Program Objectives

The literature supports the general conclusion that energy standards offer significant opportunities for advancing the market transformation objectives of PGC-funded programs. Nadel (1992) argues for a symbiotic relationship in which regulators weave strong energy saving options into codes and utility/MT programs then use these optional measures as the basis for incentive programs.

Northeast Energy Efficiency Partnerships (1998) notes that "code activities are not a substitute for new construction/renovation energy efficiency programs, but they can reduce the scale of such programs, make them more cost-effective, and provide an exit strategy for continuing incentive obligations for accepted technologies. Effective and universal code enforcement raises program baselines and reduces freeridership." This conclusion is generally supported by Nadel (1996) and Harris and Mahone (1998).

According to NEEP, energy standards offer at least three specific benefits to energy efficiency programs:

- **Financial**: When programs have largely succeeded in changing standard practice, continued program efforts may experience reduced effectiveness in stimulating new builders and developers to adopt measures. Standards can "lock in" past program accomplishments and permit the program to shift resources toward new energy efficiency opportunities.

- **Equity**: Program efforts tend to influence the largest, most aware, or most progressive market actors. Energy standards can extend program achievements to include rank-and-file market actors who tend to build to the minimum standards.
- **Level playing field**: In competitive bid situations, designers are reluctant to add measures that may save energy but have a higher first cost for fear of losing the bid. When high efficiency measures are required by code, these pressures are diminished.

Finally, NEEP notes that "the appropriate relationship between building energy codes and utility programs is for the code to require all energy efficiency measures that are now cost-effective for building owners and are common practice in the market, and for utilities to offer incentives only for those measure which exceed code, are cost-effective for society, and which need a 'market push' to lower unit costs and gain recognition and acceptance in the marketplace."

Despite the apparent benefits standards offer to energy efficiency in general and market transformation efforts in particular, a number of barriers exist to their effective implementation. Heschong Mahone Group (1998), in an assessment of the standards process in the Pacific Northwest, identify at least five barriers.

- **Standards complexity.** Standards may be difficult for users to understand, may require difficult compliance procedures, or may be difficult for building departments to enforce.
- **Standards stringency.** There may be significant vested interests opposed to further increasing the level of energy efficiency required. As HMG points out, "...increasing code stringency is an arduous administrative and political process. It provides an opening for energy code opponents to attack the entire code, and so carries some risk for those who support current codes, or who would advocate more stringent codes." Furthermore, efforts to increase standards stringency may further add to standards complexity.
- **Lack of standards knowledge.** Effective application of the standards requires an educated building design and construction community. Education is required on an on-going basis to account for turnover within that community and changes in construction practice.
- **Low building department acceptance.** Some building departments may view enforcement of standards requirements as an "unfunded mandate." Others may lack the qualified personnel necessary for adequate enforcement.
- **Low public support.** Members of the public may not see or understand the public benefits standards provide. As a consequence, they may perceive energy standards as social engineering or unnecessary government intervention.

Code simplification is critically important. Most of the jurisdictions studied are looking for simplification of the energy standards (Valley Energy Consultants 1993). The less complex the code or standard, the greater it appears that it will be used and/or enforced (Crowder and Foster 1998). It's clear from both the building and enforcement communities that the energy code needs to be simplified. This includes the code itself, compliance forms and enforcement techniques. Experience in Oregon indicates that the effectiveness of the code is improved when it is simpler to understand and apply (Heschong Mahone Group 1998).

Both Northeast Energy Efficiency Partnerships (1998) and Heschong Mahone Group (1998) argue in favor of energy efficiency program interventions to support standards activities, presumably as a consequence of the above-mentioned barriers. NEEP identifies six strategies for northeast utilities to pursue in support of energy standards, five of which may be applicable to California's utilities and PGC-funded programs.

- **Participate in standards upgrade efforts.** Programs can provide data on baseline new construction standards, make technical and program staff available to aid in the upgrade process, and provide testimony or letters of support for standards upgrades.
- **Target program activities toward emerging technologies or design techniques that are not yet standards requirements.**
- **Raise public awareness of standards requirements.**
- **Assist in trade ally training programs.**
- **Assist in standards administration and enforcement.** Utilities can require certification of standards compliance as a precondition to electrical service hook-up. They can also fund technical consultant to work with developers and building inspectors to help projects meet standards requirements. Finally they can contract with government to perform standards compliance services such as plan reviews and site inspections.

Similarly, Nadel (1992) identifies a number of options for improving coordination between energy codes and utility/market transformation programs, including

- Utility advocacy of code enhancements by proposing code changes, providing analysis of the costs and benefits of proposed code changes, and providing testimony at regulatory hearings
- Utility/MT promotion of new, stricter codes after they are promulgated but before they become mandatory
- Use of MT funds to offset code adoption costs, offer code official training, offset increased inspection costs, provide technical support, and offer incentives to cover increased building costs for the transition period
- Utility/MT promotion of Reach codes on a trial basis
- Use of sliding scale hook-up requirements and fees based upon level of code compliance

According to Wirtshafter and Hildebrandt (1992), a number of utilities and municipalities had performance-based connection fee programs in the early 1990’s including Mason County, Washington, for electric heat homes; Salem, Oregon; Hull, Massachusetts; and Commonwealth Edison of Illinois. To implement performance based connection fee programs an energy score card system is needed.

Within California, a number of innovative programs exist that provide a direct link to energy efficiency standards (Local Government Commission 1998). The County of Santa Barbara's innovative building review committee provides incentives for buildings that exceed Title 24 by 20%, 30% and 40%. EPA Energy Star homes are required to exceed Title 24 requirements by 20% to 25%. The City of San Diego's green building policy requires all municipal buildings that are built or retrofit to perform 50% above Title 24. As of December 1998, it was the only such program in the State. The City of Santa Monica was considering a similar program. In addition, the following jurisdictions have municipal programs encouraging energy efficiency in buildings exceeding Title 24:

- Alameda
- Anaheim
- The Los Angeles Department of Water and Power Service Territory
- City of Irvine
- City of San Jose
- San Luis Obispo County
- County of Santa Barbara

The City of Irvine has developed a program which refunds energy plan check and energy inspection fees to builders who participate in their program (City of Irvine 1997). Program requirements include the following:

- Guidelines for installation of wall and ceiling insulation and draft-stopping
- Use of UL181 materials and specifications for duct connection sealing
- Duct Blaster sampling protocol (target of 50 cfm/1000 ft2 of floor area)
- Supply airflow measurement at all registers with a minimum 80% of design flow at any one register, with a sum at least 90% of total design airflow.
- Duct leakage of less than 5%, to be verified by independent inspections

Results indicate that the PG&E Comfort Home Program increased both the frequency and the level of compliance with the 1988 T24 standards, although the source energy cooling savings were found to be less that the 10% target PG&E had defined. CCH "audited" compliance margin was found to be 14.2% vs. 7.6% for non-participants (Eley & Associates 1993). A 1994 follow-up study by Eley and Associates found PG&E's RNC program increased the frequency and level of compliance. The compliance margin of participating homes was nearly twice as great as that for nonparticipants. Nonparticipant homes were more than ten times as likely to fail to comply than participant homes. Vine (1996), citing a 1994 study by Frankel and Baylon, found that utility programs in Oregon had a similar significant impact on compliance. The study concludes that "while the data are very limited, it appears utility programs can be successful in making sure that homes built in their programs exceed the state energy code."

Finally, Modera and Wilcox (1995), found that ongoing program incentives are not always necessary to maintain improvements in construction practices. According to that report, field experience in North Carolina and Florida shows that HVAC contractors, after completing program-sponsored duct installation training, continued installing tight duct systems without any utility incentive.

References

Air Conditioning Contractors of America. 1986. *Residential Load Calculation—Manual J*. Air Conditioning Contractors of America.

Air Conditioning Contractors of America. 1995. *Residential Duct Systems—Manual D.* Air Condition Contractors of America.

Alliance to Save Energy. 1998. "Opportunity Lost: Better Energy Codes for Affordable Housing and a Cleaner Environment." Washington D.C.: The Alliance to Save Energy.

Alliance to Save Energy. 1998. "Opportunity Lost—A National and State Analysis of the 1993 Model Energy Code." Washington D.C.: The Alliance to Save Energy.

Alliance to Save Energy. Undated. *Energy Efficiency Financing—A Lender's Guide for Taking Advantage of this Emerging Market*. Washington, D.C.: The Alliance to Save Energy.

Barakat & Chamberlin. 1997. "Residential New Construction: Market Transformation Study." *Southern California Edison and Pacific Gas & Electric.*

Barber, et al. Building Commissioning Association—Building Commissioning Attributes. *BCA-NW.*

Baston, D. 1998. "Utility Strategies to Improve Building Energy Codes: New Opportunities in a Restructured Industry Environment—Prospectus, Draft 2." *Northeast Energy Efficiency Partnerships, Inc.*

Baylon, D. and K. Madison. 1999. "Compliance With the 1994 Nonresidential Washington State Energy Code." *1998 ACEEE Summer Study on Energy Efficiency in Buildings Proceedings Volume 5:* 5:19-25.

Baylon, D. and K. Madison. 1996. "The 1994 Washington State Nonresidential Energy Code: Quality Assurance Program Results." *1996 ACEEE Summer Study on Energy Efficiency in Buildings Volume 5:* 5.19–25.

Berkeley Solar Group. 1995. "Energy Characteristics, Code Compliance, and Occupancy of California 1993 Title 24 Houses." *California Energy Commission* Report P400-91-031CN.

Bergstan, R. 1995. "Commissioning Energy Systems: The Way Through the Maze." *Oregon Energy Report* (January).

Brady, R.C. and C. Dasher. 1998. "Building Commissioning as an Insurance Loss Prevention Strategy." *1998 ACEEE Summer Study on Energy Efficiency in Buildings Volume 4:* 4.29–36.

Building Industry Institute, ConSol, 1998. *Builder Energy Code Training Final Report: 1995-1998*. Department of Energy, California Energy Commission, Contract #400-95-002

Burati, J.L., et al. 1992. “Cause of Quality Deviations in Design and Construction.” Journal of Construction Engineering and Management.

Burati, J.L., et al. 1992. “Quality Management in Construction Industry.” Journal of Construction Engineering and Management.

California Energy Commission. 1991. “Energy Efficiency Standards For Residential and Nonresidential Buildings*.” California Energy Commission*.

California Energy Commission. 1995. “Nonresidential Manual for Compliance with the Energy Efficiency Standards.” *California Energy Commission*.

California Energy Commission. 1995. “Residential Manual for Compliance with the Energy Efficiency Standards.” *California Energy Commission.*

California Energy Commission, 1997. *Is What You See, What You Get*? Energy Evaluation Conference.

California Energy Commission. 1998 “Nonresidential Manual for Compliance with the Energy Efficiency Standards.” *California Energy Commission*.

California Energy Commission. 1998. “Residential Manual for Compliance with the Energy Efficiency Standards.” *California Energy Commission.*

California Energy Commission. 1999. “CEC’s Residential Quality Assessment Project Work Statement*.” California Energy Commission*.

California Energy Commission. 1999. “Residential Manual for Compliance with the 1998 Energy Efficiency Standards for Low-Rise Residential Buildings.” *California Energy Commission Report P400-98-002.*

Chao, M., D.B. Goldstein, and T.P. Conlon. 1998. “Energy Costs and Valuation of Commercial Properties by Appraisers and Lenders.”*1998 ACEEE Summer Study on Energy Efficiency in Buildings Volume 4:* 4.63–70.

City of Irvine. 1997. “Irvine Quality Plus—Performance Based Energy Conservation*.” City of Irvine.*

Claridge, D.E., J. Haberl, M. Liu, J. Houcek, and A. Athar. 1994. “Can You Achieve 150% of Predicted Retrofit Savings? Is It Time for Recommissioning?” *1994 ACEEE Summer Study on Energy Efficiency in Buildings Volume 5:* 5.73–87.

Coito, F., G. Syphers, A. Lekov, and V. Richardson. 1998. “Are Your Ducts All in a Row? Duct Efficiency Testing and Analysis for 150 New Homes in Northern California.” *1998 ACEEE Summer Study on Energy Efficiency in Buildings Volume 1:* 1.33–41.

Connor, M.C. 1996. “Commissioning Digital Control Systems for HVAC.” *1996 ACEEE Summer Study on Energy Efficiency in Buildings Volume 10:* 10.15–20.

ConSol, Inc. 1999. “Protocols for Energy Efficient Residential Building Envelopes. *California Institute of Energy Efficiency Project Report.*

ConSol, and LBNL. 1999. “Improving the Energy Efficiency of Air Distribution Systems in New California Homes.” *California Institute of Energy Efficiency Project Report.*

Council of American Building Officials. 1997. “An Introduction to Model Codes*.”* Council of American Building Officials.

Crowder, H. and C.R. Foster. 1998. “Building Energy Codes: New Trends.” *1998 ACEEE Summer Study on Energy Efficiency in Buildings Volume 10:* 10.3110.40.

Customer Opinion Research. 1999. “Local Government Initiatives Energy Efficiency Research.” *Opinion Dynamics Corporation.*

Czeschin, L.A., M.W. Sachi, M.J. Hewett, D.D. Vavricka, and P. McKellips. 1994. “Lighting Code Compliance in New Small Commercial Construction in Minnesota.” *1994 ACEEE Summer Study on Energy Efficiency in Buildings Volume 6:* 6.59–66.

Davis Energy Group. 1991. “Volume I: Final Report Residential Water Heating Study.” *California Energy Commission Project* #400-88-003.

Davis, et al. 1993. *Using the Pressure Pan Technique to Prioritize Duct Sealing Efforts: A Study of 18 Arkansas Homes.*

Department of Energy. 1999. “National Conference on State Building Energy Codes—Buildings for the 21st Century.” *DOE/WSU conference proceedings*.

Dodds, D., C. Dasher, and M. Brenneke. 1998. “Building Commissioning: Maps, Gaps & Directions.” *1998 ACEEE Summer Study on Energy Efficiency in Buildings Volume 4:* 4.133–143.

Dodds, D., T. Haasl, C. Chappell, and C. Kjellman. 1994. “How Much Does Commissioning Cost and How Much Does It Save?” *1994 ACEEE Summer Study on Energy Efficiency in Buildings Volume 5:* 5.90–95.

E-Cube, Inc. “Commissioning Cost Effectiveness.” E-Cube, Inc.

E-Cube, Inc. “Commissioning Project List.” E-Cube, Inc.

E-Cube, Inc. “Commissioning: what and why.” E-Cube, Inc.

E-Source. 1994. “Energy-Efficient Buildings: Institutional Barriers and Opportunities.” E-Source Strategic Issues Paper.

Edmunds, D. and T. Haasl. 1998. “The Role of Existing Building Commissioning in the State of Tennessee’s Energy Management Program.” *1998 ACEEE Summer Study on Energy Efficiency in Buildings Volume 4:* 4.145–155.

Eley & Associates. 1994. “PG&E California Comfort Homes Title 24.” *Pacific Gas & Electric Company*.

Eley & Associates. 1999. “Capitol East End Office Complex Commissioning.” *California Energy Commission.*

Eley, C., J. Kennedy, L. Parkerk, and I. Porter. 1994. “Commercial Building Code Development in Australia.” *1994 ACEEE Summer Study on Energy Efficiency in Buildings Volume 6:* 6.67–79.

Farhar, B.C. and J. Eckert. 1993. “Energy-Efficient Mortgages and Home Energy Rating Systems: A Report on the Nation's Progress.” *United States Department of Energy Study.*

Farhar, B.C., N.E. Collins; and R.W. Walsh. 1996. “Linking Home Energy Rating Systems with Energy-Efficiency Financing: Progress on National and State Programs.” *United States Department of Energy Study.*

Farhar, B., N.E. Collins; and R.W. Walsh. 1997. “Case Studies of Energy Efficiency Financing in the Original Five Pilot States, 1993-1996. *United States Department of Energy Study.*

Goldberg, M.L. 1996. “Reasonable Doubts” Monitoring and Verification for Performance Contracting.” *1996 ACEEE Summer Study on Energy Efficiency in Buildings Volume 4:* 4.133–143.

Greening, L.A., A. Sanstad, J.E. McMahon, T. Wenzel, and S.J. Pickle. 1996. “Retrospective Analysis of National Energy Efficiency Standards for Refrigerators.” *1996 ACEEE Summer Study on Energy Efficiency in Buildings Volume 9:* 9.101–109.

Hammon, R. and M. Modera. 1999. “Improving the Energy Efficiency of Air Distribution Systems in New California Homes.” *California Institute for Energy Efficiency Project Report.*

Harris, J. and D. Mahone. 1998. “Energy Codes and Market Transformation in the Northwest: A Fresh Look.” *1998 ACEEE Summer Study on Energy Efficiency in Buildings Volume 7:* 7.123–134.

Heschong, L., J. Sugar, and J. Benya. 1998. “What are the Next Steps for Lighting Efficiency Policy? Reporting on a Statewide California Study.” *1998 ACEEE Summer Study on Energy Efficiency in Buildings Volume 4:* 4.193–204.

Heschong Mahone Group. 1998. “A Long-Term Strategy for Energy Code Support in the Northwest.” *Northeast Energy Efficiency Alliance.*

Heschong Mahone Group. 1997. *California Baseline Lighting Technology Report*, California Energy Commission.

Howarth, R. and B. Andersson. 1993. “Market Barriers to Energy Efficiency.” *Energy Economics.*

Jagemar, L. and L. Andersson. 1996. “Design and Commissioning of an Energy Efficient Air Distribution System in a University Hospital.” *1996 ACEEE Summer Study on Energy Efficiency in Buildings Volume 4:* 4.193–200.

Jones, Ted and D. Norland. 1996. “The 1993 Model Energy Code: Energy and Environmental Savings, Costs and Benefits by State.” *1996 ACEEE Summer Study on Energy Efficiency in Buildings Volume 2:* 2.119–125.

Kaplan, M. “Issues in commissioning Administration, Process, and Technique—A Case Study Collage.” *Kaplan Engineering.*

Kolderup, Eley, and Heschong. 1998. “California Lighting Model.” *Proceedings of the American Council for an Energy Efficient Economy 1998 Summer Conference.*

Koomey, J.G., C. Dunham, and J.D. Lutz. 1994. “The Effect of Efficiency Standards on Water Use and Water Heating Energy Use in the U.S.: A Detailed End-Use Treatment.” *1994 ACEEE Summer Study on Energy Efficiency in Buildings Volume 7:* 7.103–112.

Kromer, S.J. and S.R. Schiller. 1996. “National Measurement and Verification Protocols.” *1996 ACEEE Summer Study on Energy Efficiency in Buildings Volume 5:* 5.141–146.

Kunkle, R. 1997. “The Washington State Energy Code: Certification for Inspectors and Plan Reviewers for the Non-Residential Energy Code.” *Washington State University.*

Kunkle, R. 1997. “The Washington State Energy Code: Energy Code Privatization—The Utility Code Group Story.” *Washington State University.*

LBNL, Environmental Energy Technologies Division. “Insurance Loss Prevention Through Sustainable Energy Technologies.”

Lindstrom, A., et al. 1995. “Effects of Modified Residential Construction on Indoor Air Quality.” *International Journal of Indoor Air Quality and Construction.*

Local Government Commission. 1998. *Improving Energy Efficiency in Buildings: Untapped Savings Opportunities for Local Communities*.

Madison, K. and D. Baylon. 1998. “Compliance with the 1994 Nonresidential Washington State Energy Code.” *1998 ACEEE Summer Study on Energy Efficiency in Buildings Volume 4:* 4.249–259.

Madison, K., T.J. Usibelli, and J.P. Harris. 1998. “The Washington State Non-Residential Energy Code: A New Model Process for Code Development.” *1994 ACEEE Summer Study on Energy Efficiency in Buildings Volume 6:* 6.139–148.

McMahon, J.E., S.J. Pickle, I. Turiel, P. Chan, T. Chan and C.A. Webber. 1996. “Assessing Federal Appliance and Lighting Performance Standards.” *1996 ACEEE Summer Study on Energy Efficiency in Buildings Volume 9:* 9.159–165.

Mills, E., A. Deering, and E. Vine. 1998. “Energy Efficiency: Proactive Strategies for Risk Managers.” *Risk Management Magazine.* (March): 12–16.

Minter, J. 1998. “The Fruits of the Commissioning Process.” *E-Design*

Modera and Hammon. 1999. “Improving the Energy Efficiency of Residential Air Distribution Systems.” *California Institute of Energy Efficiency Project Report.*

Modera, M. and B. Wilcox. 1995. “Treatment of Residential Duct Leakage in Title-24 Energy Efficiency Standards.” *California Energy Commission Report. Contract #400-91-031.*

Nadel, S. 1992. “Improving Coordination Between State Energy Codes and Utility New Construction Programs.” 1992 *ACEEE Summer Study on Energy Efficiency in Buildings*.

Nadel, S. 1996. “Providing Utility Energy Efficiency Services in an Era of Tight Budgets: Maximizing Long Term Energy Savings While Monitoring Utility Costs.” *1996 ACEEE Summer Study on Energy Efficiency in Buildings*.

Narel, T. and T. Haasl. 1994. “The Business of Running Buildings: Whose Business Is It?.” *1994 ACEEE Summer Study on Energy Efficiency in Buildings Volume 5:* 5.175–179.

Neal. 1998. “Field Adjusted SEER (SEERFA).” *Proceedings of the American Council for an Energy Efficient Economy 1998 Summer Conference.*

Neme, Proctor, and Nadel. 1999. *National Energy Savings Potential From Addressing Residential HVAC Installation Problems.* U.S. EPA Energy Star program report.

NEOS Corporation 1997. “Comparison of Residential Building Standards Projects*.” California Energy Commission* Report P400-94-015ACN.

NEOS Corporation, 1997. “Post Occupancy Residential Survey 3/97”. *California Energy Commission. Contract #P400-94-015CN*

O’Neill, P. and K. Radke. 1994. “Automating the Commissioning Process—Information Management in Building Design Through Occupancy.” *1994 ACEEE Summer Study on Energy Efficiency in Buildings Volume 5:* 5.193–199.

Oregon Office of Technology. 1999. “Building Commissioning Case Studies. *Oregon Office of Technology Online Article.*

Oregon Office of Technology. 1999. "Savings from Energy Commissioning." *Oregon Office of Technology Online Article*.

Oregon Office of Technology. "Commissioning Buildings in the Northwest." *Oregon Office of Technology Report.*

Pacific Gas & Electric. 1994. "1992 PG&E California Comfort Home Title 24 Compliance Study." *Prepared by Eley & Associates*.

Pacific Gas & Electric Company. 1998. "1998 Customer Energy Efficiency Programs," *Advice Filing 2086-G/1776-E, Attachments*.

Pacific Gas & Electric Company. 1998. "1999 Customer Energy Efficiency Programs," *Advice Letter 2177-G/1819-E, Attachments*.

Perich-Anderson, J. and L. Dethman. 1994. "How Well Is Our Energy Code Working? An Evaluation of the Tacoma, Washington Model Conservation Program." *1994 ACEEE Summer Study on Energy Efficiency in Buildings Volume 6:* 6.150–156.

Peterson, J.C. and T. Haasl. 1994. "A Commissioning Cost-Effectiveness Case Study." *1994 ACEEE Summer Study on Energy Efficiency in Buildings Volume 5:* 5.201–208.

Piette, M.A., and B. Nordman. 1995. "Commissioning of Energy-Efficiency Measures: Costs and Benefits for 16 Buildings." *Lawrence Berkeley National Laboratory Report.*

Piette, M.A., and B. Nordman. 1995. "Costs and Benefits from Utility-Funded Commissioning of Energy Efficient Measures." *Lawrence Berkeley National Laboratory Conference Proceedings.*

Portland Energy Conservation, Inc. 1997. "What Can Commissioning Do For Your Building?" *Portland Energy Conservation, Inc.*

Portland Energy Conservation, Inc. 1999. "Building Commissioning Activities in the US.." *Portland Energy Conservation, Inc.*

Portland Energy Conservation, Inc. 1999. 7th National Conference on Building Commissioning. *Conference Proceedings*. Portland, OR: May 3–5.

Q Associates, National Renewable Energy Lab., University of Vermont. 1996. "Linking Home Energy Rating Systems with Energy-Efficiency Financing: National and State Programs."

Reichmuth, H.S. and K.C. Fish. 1994. "Case Study in Building Commissioning and Savings Verification Applied to a 311,000 ft^2 Office Tower Retrofit." *1994 ACEEE Summer Study on Energy Efficiency in Buildings Volume 5:* 5.209–218.

Regional Economic Research, 1999. "1998 PG&E Comfort Home Program Market Baseline and Market Effects Study." *PG&E Study 420ms-e.*

Research Into Action, PCS, Megdal & Associates. 1998. “Market Effects Summary Study.” *CADMAC Study Volume 2.*

RLW Analytics, Inc. 1999. “Final Report: Non-Residential New Construction Baseline Study.” *California Board for Energy Efficiency*.

SBW Consulting. 1998. “Building Commissioning Practices in New Construction and Existing Building Markets in the Pacific Northwest.” Northwest Energy Efficiency Alliance.

Schiller, S.R. and J.S. Kromer. 1998. “Measurement and Verification Protocols—Facts and Fiction, News from the Field.” *1998 ACEEE Summer Study on Energy Efficiency in Buildings Volume 4:* 4.341–350.

Skumatz, L. and C.A. Dickerson. 1998. “Extra! Extra! Non-Energy Benefits Swamp Loan Impacts for PG&E Program!.” *1998 ACEEE Summer Study on Energy Efficiency in Buildings Volume 8:* 8.301-312

Syphers, G., Lekov, A., and V. Richardson, 1998. *Are All Your Ducts in a Row?* American Council for an Energy Efficient Economy.

TecMRKT Works. 1998. “PG&E Energy Center Market Effects Study.” *Pacific Gas & Electric.*

Tseng, P.C. 1998. “Building Commissioning: Benefits and Costs.”

Tseng, P.C., D.R. Stanton-Hoyle, and W. Withers. 1994. “Commissioning Through Digital Controls and an Advanced Monitoring System—A Project Perspective.” *1994 ACEEE Summer Study on Energy Efficiency in Buildings Volume 5:* 5.237–247.

True, B. 1994. “Incentives and Standard to Promote Economic and Energy Efficiency.” *1994 ACEEE Summer Study on Energy Efficiency in Building Volume 6:* 6.-221-229*.*

Turiel, I. and S. Hakim. 1996. “Consensus Efficiency Standards for Refrigerators and Freezers—Providing Engineering/Economic Analyses to Aid the Process.” *1996 ACEEE Summer Study on Energy Efficiency in Buildings Volume 9:* 9.207–215.

Usibelli, T. 1997. “The Washington State Energy Code: The Role of Evaluation in Washington State's Non-Residential Energy Code.” *Washington State University.*

Valley Energy Consultants. 1993. “Monitoring Final Report.” *California Energy Commission. Contract No.: 400-91-032*

Valley Energy Consultants. 1994. “Monitoring Final Report.” *California Energy Commission. Contract No.: 400-91-032*

Valley Energy Consultants. 1995. “1994-1995 Monitoring Final Report.” *California Energy Commission. Contract No.: 400-93-022*

Valley Energy Consultants. 1996. “1995-1996 Building Department Monitoring Report.” *California Energy Commission. Contract No.: 400-93-022*

Verdict, M. 1996. “Making the American Dream More Affordable Through Energy Efficiency Financing.” *1996 ACEEE Summer Study on Energy Efficiency in Buildings Volume2:* 2.215-219.

Verdict, M.E., P.W. Fairey, and M.C. DeWein. 1998. “Home Energy Ratings and Energy Codes—A Marriage That Should Work.” *1998 ACEEE Summer Study on Energy Efficiency in Buildings Volume 2:* 2.231–241.

Vieira, R., J.E. Cummings, P.W. Fairey, and K. Hannani. 1999. “How to Calculate Financial Information for Home Energy Raters, Lenders and Savvy Home Buyers.” *1998 ACEEE Summer Study on Energy Efficiency in Buildings Proceedings.*

Vine, E.L. 1995. “Residential New Construction Programs: Going Beyond the Code.” *Report from the Database on Energy Efficiency Programs (DEEP) Project.*

Vine, E.L. 1996. “Residential Building Code Compliance: Implications for Evaluating the Performance of Utility Residential New Construction Programs.” *1996 ACEEE Summer Study on Energy Efficiency in Buildings Volume 3:* 3.161–168.

Vine, E., E. Mills, and A. Chen. 1998. “Energy-Efficiency and Renewable Energy Options for Risk Management and Insurance Loss Reduction: An Inventory of Technologies, Research Capabilities, and Research Facilities at the U.S. Department of Energy's National Laboratories.” *Berkeley, CA: Ernest Orlando Lawrence Berkeley National Laboratory, LBNL-41432.*

Vine, E.L.; E. Mills, and A. Chen. 1999. “Tapping Into Energy.” *Best’s Review Property and Casualty.* (May).

Vogt, T and P. Ignelzi. 1994. “California Home Energy Efficiency Rating System (CHEERS) Early Program Evaluation. *Pacific Consulting Services.*

Walsh, R.W., N. E. Collins, and B.C. Farhar. 1997. “Home Energy Ratings and Energy Efficiency Financing: Guidelines for Designing and Implementing a Program.” *1997 Evaluation Conference.*

Wang, J. 1996. “Energy Characteristics and Code Compliance of California Houses.” *1996 ACEEE Summer Study on Energy Efficiency in Buildings Volume 3:* 3.181–187.

Waterbury, S.S., D.J. Frey, and K.F. Johnson. 1994. “Commercial Building Performance Evaluation System for HVAC Diagnostics and Commissioning.” *1994 ACEEE Summer Study on Energy Efficiency in Buildings Volume 5:* 5.249–255.

Werling, E.; J.D. Hall, D. Meisegeier, S. Rashkin, B. Collison, and G. Chinery. 1998. “Lessons Learned In The Energy Star Home Program.” *1998 ACEEE Summer Study on Energy Efficiency in Buildings Volume* 2: 2.234-257.

Wilcox, B.A. and M. Hunt. 1996. “Comparison of CHEERS Energy Use Predictions with Actual Utility Bills.” *1996 ACEEE Summer Study on Energy Efficiency in Buildings Volume* 1: 1.385-399.

Williams, D.S., D. Horgan, B. Tibbetts, M. Rudman, and R. Oberg. 1997. “Is What You See, What You Get?” *1997 International Energy Program Evaluation Conference.*

Williamson, P., B. Koran, G. Wallace, and W. Stamper. 1994. “Capturing Lost Opportunity in the High-Tech Building Market Through Commissioning.” *1994 ACEEE Summer Study on Energy Efficiency in Buildings Volume 5:* 5.267–274.

Wirtshafter, R. and E. Hildebrandt. 1992. “Energy Performance Based Connection Fees: A Case Study in New York State.

Wray, C. Piette, M., Sherman, M., Levinson, R., Driscoll, D., McWilliams, J., Matson, N., Xu, T., and W. Delp, 1999.*Residential Commissioning a Review of Related Literature*. California Energy Commission. Contract #DE-AC03-76SF00098

Xenergy. 1999. “Compilation and Analysis of Currently Available Baseline Data on the California Energy Efficiency Markets Study (CABD).” *California Board for Energy Efficiency.*

Xenergy. 1996. Innovative Financing of Home Efficiency Improvements. *1996 ACEEE Summer Study on Energy Efficiency in Buildings.*

Xenergy. 1998. “PG&E and SDG&E Commercial Lighting Market Effects Study—Final Report.” *PG&E/SDG&E Volume 1.*

Yoder, R.A. and M.B. Kaplan. 1994. “Cost-Effective Commissioning: Getting the Job Done Within Utility Guidelines.” *1994 ACEEE Summer Study on Energy Efficiency in Buildings Volume 5:* 5.275–282.

York D. and D. Sumi. 1997. Understanding the Market for Building Commissioning in Wisconsin.” *1997 International Energy Program Evaluation Conference.*

Addendum-Reviewer Comments on Literature Review

FF February 10, 2000

Typical California residential wall framing practice results in far more wood being used than is necessary to insure structural integrity. Additional framing not all wastes limited wood resources, but also results in diminished thermal performance of the building envelope. The energy impact of wall framing is addressed by the term "framing factor". The framing factor of a wall represents the area of wood penetrating the wall cavity divided by the net wall area (gross area minus any windows or doors). Framing that penetrates the wall cavity includes studs, cripples, top and bottom plates, and headers. As the framing factor increases the percentage of the wall that is insulated by wood (at ~R-1 per inch) increases relative to the percentage that is insulated by insulation (at about R-3.7 per inch).

For standard 2x4 construction with studs on 16" centers, framing factors have until recently been assumed to be 15% (ASHRAE Fundamental 1985). The 15% assumption represents little more than the framing found in a clear wall section where studs are uniformly placed on 16" centers. Field measurements have shown much higher framing factors due to window and door framing details, headers, blocking, corners, interior wall junctions, and framing on intervals less than 16". A 1992 survey of six framed houses in Davis, CA indicated framing factors ranging from 30 to 35%. Many energy professionals pushed ASHRAE to revise the framing factor assumption to more accurately represent reality. In the 1993 ASHRAE Fundamentals, the framing factor for 2x4 construction (16" on center) was raised from 15% to 25%.

The theoretical impact of increased framing can be easily quantified using ASHRAE's parallel path calculation methodology. Hot box testing of wall systems has been, such as that performed at Oak Ridge National Laboratory's Buildings Technology Center (Energy Design Update September 1999) can be used to calculate effective R-values for different wall assemblies. However, no data was found in the literature documenting the annual energy impact of additional wall framing in California climates. Since exterior foam insulation (typically R-4 or R-5) is common for a significant fraction of the California production home market, the annual energy impact of underestimating wall framing may be small, especially in mild climate areas.

Alternative reduced-framing wall systems, optimized framing system design (NAHB 1977), and framing contractor education could all contribute to reducing the energy use and material consumption in California homes. A 1994 study of steel framing practice in four California houses found framing factors ranging from 23 to 34% (Davis Energy Group 1994). Despite the much higher strength of steel, framers were apparently following standard wood framing practice and therefore not realizing any energy benefits due to reduced wall framing.

References:

1. ASHRAE. 1985. 1985 Fundamentals. Chapter 22. American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., Atlanta, GA.

2. ASHRAE. 1993. 1993 Fundamentals. Chapter 22. American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. Atlanta, GA.

3. Energy Design Update. September 1999. How Thermal Shorts and Insulation Flaws Degrade an "R-19" Stud Wall to a Measly "R-11". Cutter Information Corporation. Arlington, MA.

4. NAHB. 1977. Reducing Home Building Costs with Optimum Value Engineered Design and Construction. NAHB Research Foundation. Upper Marlboro, MD.

5. Davis Energy Group. 1994. Steel Wall Framing in California: A Study for the Intervenor Award Program.

Recessed ceiling lighting has become an increasingly common feature in new California production homes. Two problems associated with recessed lighting relate to ceiling insulation integrity and envelope air-tightness. Although current Residential Mandatory Measures (California Energy Commission 1999) require incandescent recessed lights to be approved for zero-clearance insulation cover (IC-rated), some insulation installers do not regularly insulate them creating multiple insulation voids. In addition, recessed lights create potential infiltration paths to the attic space or the buffer space between floors, which is typically well connected to outdoors. The Energy Commission's Residential Quality Assessment Project will assess the magnitude of these issues.

Zong February 1, 2000

Control of air distribution zones within a house allows for matching of comfort requirements in different areas of a house. Most two-story houses feature living space downstairs and bedrooms upstairs. Installation of a zoned HVAC system, including a second thermostat and zone dampers, allows for individual control of temperatures in each zone. A zoned system provides better comfort control since it allows space conditioning to be directed to the area of the house requiring heating or cooling. (Typically, stratification causes first floor heating and second floor cooling requirements to be higher.) Optimized thermostat control would condition the living zone during the day and the sleeping zone during the night, and relax setpoints during unoccupied times.

A 1989 study of a commercially available zoning system monitored heating system performance in a two-story house in Sacramento (Davis Energy Group 1989). The zoning system installed in this house was found to reduce the amount of stratification between floors by 3.7 degrees F, and the amount of floor-to-ceiling stratification by 0.3 degrees F. The reduction in stratification was created by extending furnace fan operation both at the end of furnace heating cycles and also during periods when the temperature difference between floors exceeded about 5 degrees F.

Modelling of this zoning and destratification system was performed in the 1989 study using the MICROPAS hourly simulation model. Annual heating energy savings of 14-17% were projected for the Sacramento climate with negligible cooling savings. A key factor relating to the projected savings is how occupant control affects zoning system performance. No data was found in the literature review evaluating this affect, although in a worst case situation it may be reasonable to assume that no heating benefits may be realized.

The current configuration of this zoning system being marketed only runs the extended fan destratification cycle in conjunction with furnace operation. This may reduce savings slightly although it also reduces parasitic fan energy consumption. A major Northern California HVAC contractor estimates that approximately 60% of the two-story homes they work on install the zoning system with an increasing share of homes in the San Francisco Bay Area.

Bill Pennington January 24, 2000

I've not been able to get through the whole report, but I'm going to be unavailable for the next couple of days so I wanted to get you comment on what I've looked at.

The "Key Measures Reviewed," "Definitions of Measure Installation Effectiveness," and "Status of Measure Installation Effectiveness" mixes compliance issues in with installation effectiveness. Installation effectiveness should be thought of as "if a measure is installed, does it have the performance (from an energy efficiency standpoint primarily) that is expected?" Compliance in terms of whether or not a measure is present is a topic for other studies. There are not adequate funds in this contract to do a good job on both installation effectiveness (through performance testing and building commissioning) and compliance issues. That's why there is no reference to compliance in the RFP's study objectives.

The "Definitions of Measure Installation Effectiveness" identify compliance issues rather than performance issues for Residential: lighting, duct insulation, roof/wall insulation, water heating, and pipe insulation and Nonresidential: lighting power density, equipment efficiency, and high performance windows. These are outside the scope of the project.

The "Status of Measure Installation Effectiveness" focus substantially on compliance issues rather than performance issues for Residential Lighting (p. 3), duct insulation (p. 6), interior window shades (p. 7), Residential water heating (p. 8).

The "Residential Measures with Noteworthy Performance Issues" include several measures due to conclusions about compliance issues. There are clear performance issues for duct design and airflow, duct sealing, HVAC installation, envelope sealing and air barrier, and insulation quality. Justification for inclusion of these features can be found in the DEG Residential Construction Quality Assessment Contract, the LBNL Residential Commissioning project and in the extensive "house as a system" and "building performance" literature. Additional performance issues are: in situ equipment efficiency (see Proctor reports), framing factor (see DEG reports, ASHRAE Handbook, ORNL projects, and Res Construction Quality Assessment Contract), and excessive building envelope leakage due to recessed can down lights (see DEG Res Construction Quality Assessment Contract, this is the only residential lighting performance issue that I'm aware of). Two other performance issues that may not be well documented are 1) roller shades or mini-blinds not being an effective shading device because once solar gain is inside the window most of it doesn't get reflected back out, 2) residential zonal control not really being effective at isolating zones so that in reality whole house gets heated or cooled and energy savings is far less than expected.

The "Status of Measure Installation Effectiveness" also focus substantially on compliance issues rather than performance issues for Nonresidential Lighting Measures (except for the next to the last bullet in this section on p. 10 relating to occupancy sensor performance), and Nonresidential HVAC Measures (except for the last bullet in this section on p. 11 relating to VAV boxes). This discussion of compliance issues is outside the scope of the project.

I agree with the lists on p. 11 for "in" and "out" measures, except equipment efficiency probably should be in based on failure to perform as expected. But these lists should be determined by literature related to performance problems in the field (see PG&E project on roof top air units, Building Commissioning problems, etc.) not on literature about compliance.

I thought the "Roles and Attitudes of Key Market Actors" was pretty good. The example about R-15 batts on p. 13 is not a good one - insulation contractors don't make decisions on framing type and higher R-values can be achieved using rigid insulation (again a builder not insulation contractor decision). The statement about realtors playing an important role in home purchases (next paragraph) is not true for new production homes (builder's sales agents) which are the vast majority of new houses. Nonresidential Building Owners also care about property value, rentability, operating cost for owner-occupied, profitability for REITs and institutional investors (p. 14). Discussion of different Nonresidential design models should point out that architect-driven model has less accountability for correcting design/construction performance problems because of "finger pointing." Design/build model can correct this accountability problem. This section needs to talk about performance contracting for new nonresidential buildings based on Eley's work and also work at Rocky Mountain Institute.

I liked the section on Building Commissioning. There are a lot of good leads here that need to be followed up. I would expect industry experts would identify additional literature of value. Talk to Piette, BCA, PG&E, SMUD, Edison about commissioning experience in California. The governmental commissioning requirements should be explored in depth, as should the Energy Star and FEMP requirements. Another angle on insurance companies (p. 21) is that they own a lot of large nonresidential buildings as investors and should be motivated to doing commissioning as a way to increase investment profitability. I got through p. 24 so far.