

Final Report

California Commissioning Market Characterization Study

A Report Prepared for Pacific Gas and Electric Company

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California Commissioning Market Characterization Study

Executive Summary

Introduction

Commissioning is increasingly recognized as a cost-effective method of ensuring building performance, reducing energy use, and improving indoor air quality, occupant comfort and productivity. Over the past ten years, utilities in California and across the United States have been important supporters of the commissioning industry and their support has led to significant energy savings. However, in 1998, it was still estimated that less than 5% of all commercial new construction and less than 0.03% of existing buildings were commissioned each year.¹ Although the percentage of buildings being commissioned each year has most likely increased since 1998, substantial energy saving opportunities clearly still exist.

Many indicators show that the commissioning industry is about to enter a period of expansion. Larger architectural and engineering firms are entering the commissioning market. The number of participants at the National Conference on Building Commissioning is increasing steadily (from 135 participants in 1993 to 326 in 1999). Manufacturers of HVAC equipment are developing models with self-diagnostic capabilities that would facilitate commissioning. Several states, including California, are considering legislating commissioning requirements. It is therefore an ideal time to re-evaluate the market and assess how utilities can support and catalyze this new period of market transformation.

Pacific Gas and Electric Company (PG&E) hired PECI to characterize current California commissioning practices and provide important information on how to increase quality commissioning services. The first part of the study (Task 1) entailed a literature search to determine:

- ✍✍ The definition of commissioning from various market actor's perspectives;
- ✍✍ The infrastructure of the commissioning market. This includes who the main market actors are, what their roles and responsibilities are, and how many actors there are in California;
- ✍✍ The history and expected evolution of commissioning. A historic evolution and current development of commissioning tools is also discussed;
- ✍✍ The current commissioning activities. This includes programs, policies, and projects being used throughout the United States.

A separate report (*Literature Review to Characterize Commissioning Market Infrastructure*) provides the results of the literature search.

The second part of the study (Task 2) entailed developing and administering two surveys, one for vendors (commissioning providers) and other for customers (building owners). Twenty-four owners and twenty-five commissioning providers participated. Several types of vendors are represented such as architects, engineers, building commissioning consultants, testing and balancing contractors, design-build contractors, and controls contractors. Over 50% of the vendors surveyed are from engineering firms. Almost half the firms employ ten or fewer people. This includes one quarter of

¹ PECI. 1998. National Strategy for Building Commissioning. U.S. Department of Energy.

the respondents who are independent consultants, working alone. Building owners are from both the public and private sector. The range of building types include hospitals, research facilities, low and high rise office buildings, retail facilities, and universities. The following summarizes some of the key findings from the survey:

Key Survey Findings

When the size of the firm, based on the total number of employees, is compared to their annual estimated square footage of commissioning (for both new and existing buildings) the smaller firms account for at least as much commissioning as larger firms. Out of the reported 32 million square feet commissioned annually, the smaller firms (ten employees or fewer) claimed commissioning 19.5 million square feet, or 60% of the total square footage commissioned.

Over half the firms say commissioning accounts for 10% or less of their business. This is expected, as many firms, especially larger ones, offer diverse services and have not found enough demand to rely exclusively on commissioning services for their revenue. When the firms are sorted according to size (number of employees), firms specializing in commissioning tend to be smaller. The largest firm with significant commissioning activity was a firm of 35 employees.

The majority of owners define commissioning for new construction as a testing process that happens during or after construction. Less than half the owners said that they include commissioning during the design part of a project. When providers were asked to define commissioning, they said the main goal of commissioning is to verify that building performance meets the design intent. These respondents often mentioned functional testing as a method of verifying that the performance requirements are met. Less than 25% specified that commissioning assists in the development of proper design as well as the verification of meeting the design intent.

Owners are most interested in the non-energy benefits of commissioning including smoother turn over, improved comfort control and reduced construction and warranty issues. Only when prompted with a list of benefits did owners select energy savings as an important benefit that they realize from commissioning.

Owners indicated that the most significant barriers to making commissioning and retrocommissioning a part of standard industry practice are (in order of importance) lack of budget, lack of general awareness about what commissioning and retrocommissioning is, and the perceived high cost of each process. When providers were prompted with a list of barriers to their firm incorporating commissioning for new buildings as a standard business offering, over 80% of the commissioning providers selected “clients not requesting the service” as the most significant barrier. This echoes their perception from a related question, that owners lack understanding of commissioning and that owners think they are “already getting it” as part of the construction process.

Regarding ways to overcome market barriers, owners selected “low-cost or no-cost workshops” as an effective method for increasing market demand for both retrocommissioning and commissioning services along with demonstration projects and case studies that demonstrate the benefits of the processes. Ninety percent of the commissioning providers, when asked to rate strategies for increasing market demand for commissioning services, rated “educational programs for building owners and their staff” as most or very effective. Their second highest choice was to provide case studies that demonstrate the benefits of commissioning.

When asked to rate strategies for increasing demand, 65% of the providers felt that utility financing programs are very or most effective. When owners were asked a similar question, 83% of them rated the strategy as most effective. This is not surprising since three quarters of the owners cited “lack of budget” as the main barrier to requesting commissioning or retrocommissioning services.

When asked about implementation problems, commissioning providers cited a lack of cooperation by the construction contractors as a significant problem. Implementation is difficult because the contractors do not understand the process, their role, and the how it benefits them. According to the providers, contractors do not seem to understand the commissioning process. They are often resistant and lack an understanding of how to fulfill their part of the commissioning requirements. Providers suggest that contractors receive more education and training on commissioning.

Commissioning providers had mixed reactions to incorporating commissioning into the California Energy Code. Almost 50% thought that commissioning code requirements would be very effective in increasing commissioning services and about 40% thought they would be not effective or only somewhat effective. Some providers thought that code requirements would force owners to commission their buildings and as a result market demand for commissioning would increase. Others thought this scenario was unworkable because the code requirements would not be developed and enforced effectively. Two-thirds of owners surveyed felt that commissioning code requirements would be an effective way to increase market demand.

When owners were asked what types of software or assessment tools would benefit them in operating their buildings, they expressed a strong interest in automated diagnostic tools that could help them detect equipment and system problems. Respondents were largely unaware of all the new diagnostic equipment emerging in the market and instead described functions they would like to see incorporated into tools. Commissioning providers are also clearly interested in automated tools. In fact, providers rated tools to decrease delivery time - such as software tools, automated tools, and management tracking tools - as a useful method for developing commissioning skills. Both owners and providers cited several ideas for new tools that would help facilitate commissioning.

Concerning infrastructure, approximately one-third of providers are unhappy with the lack of consistency among providers, as it may give commissioning a “bad name”. When providers were asked to rate strategies for increasing the quality of commissioning, almost two-thirds of them rated “standardization of commissioning requirements” as very or most effective for increasing the quality of commissioning. Standardization of commissioning requirements was also mentioned as a way to increase the cost effectiveness of commissioning.

Cost, Savings, and Infrastructure Estimates for Commissioning in California

The third part of the study (Task 3) included developing a final report and conducting an analysis to estimate what the commissioning costs and associated energy savings might be for the State of California if commissioning were adopted in both existing buildings and new construction. The analysis also includes estimating the requirements for a commissioning infrastructure to support the effort. The following summarizes the analysis.

The analysis for both new construction and existing buildings only considers those buildings over 25,000 square feet. It was necessary to exclude small buildings in the balance of the analysis. This

exclusion is reasonable since holistic commissioning is rarely practiced in facilities smaller than 25,000 square feet, as it is currently hard to make the process cost effective.

The total square feet for existing buildings in all sectors over 25,000 square feet is 2.47 billion. When a penetration rate of 0.02 is applied, the floor area commissioned totals 49.4 million square feet annually at a cost of \$12.8 million. The unit cost included all parties and fixes and ranged from \$0.32 to \$0.47 per square foot based on an average building size and depending on market sector.

The energy savings for existing building commissioning ranged from 12% to 15% of total energy consumption with demand reductions indirectly included because the energy cost values that the savings fraction is applied to include typical demand charges. Energy savings for penetrating 2% of the buildings greater than 25,000 square feet totals 690 million kBtu annually and \$9.5 million. The simple payback from energy alone averages 1.8 years, well under its expected average “measure” life of 3 to 6 years. This makes stand-alone retrocommissioning an attractive energy conservation measure.

The number of full time commissioning providers needed to commission the 49.4 million square feet of existing buildings annually is estimated to be 165 fully experienced commissioning providers. This equates to 300,000 square feet per year per full time provider.

For new building construction the floor area for all building sectors greater than 25,000 square feet is 61.4 million square feet. When a penetration rate of 0.30 is applied, the floor area commissioned is 18.4 million square feet annually at a cost of \$20.7 million. The unit cost included the design and construction phases for all parties and ranged from \$0.87 to \$1.35/square feet depending on market sector.

The energy savings ranged from 6% to 9% of total energy consumption with demand reductions indirectly included because the energy cost values that the savings fraction is applied to include typical demand charges. Energy savings for penetrating 30% of the buildings greater than 25,000 square feet, totals 147 million kBtu annually or \$2.08 million. The simple payback from energy alone averages 9.9 years, near the top end of its average expected “measure” life of 5 to 10 years.

The number of full time commissioning providers needed to commission the 18.4 million square feet annually is estimated to be 182. This equates to 101,000 square feet per year per full time provider. The number of providers shown is for fully experienced individuals.

Conclusions

The survey findings, along with the market potential for commissioning in California, clearly indicate that there are several needs for PG&E to address that will positively impact the growth of the industry. Because much of the focus for both commissioning and retrocommissioning is on optimizing building performance that reduces energy waste, it is advantageous for PG&E to support the industry with financial incentives, educational programs, methods for ensuring quality delivery, and research and development of tools and software that expedite the commissioning process.

California Commissioning Market Characterization Study

Introduction

This market characterization study, sponsored by Pacific Gas & Electric, investigates current commissioning activities in California. It was undertaken to provide information needed to determine how Pacific Gas & Electric can support the development of the commissioning industry in California. As a part of this study, telephone surveys were undertaken to provide information on current commissioning practices and market actors' opinions on how to increase commissioning services in California. Both commissioning practitioners (providers) and building owners were interviewed. This draft report summarizes the survey results. The specific objectives of the surveys were to:

- ✍ Portray the current status of commissioning in California including services offered, methods, tools and techniques used, and data collected during commissioning.
- ✍ Identify the methods, tools, techniques, training activities, and marketing materials that are needed to increase commissioning activities or improve commissioning quality.
- ✍ Identify ways to overcome existing market barriers and increase the use of commissioning.

In addition, based on an analysis of the survey results, we have outlined recommendations on how Pacific Gas & Electric can support and catalyze the growth of the commissioning market.

Approach

Two telephone survey instruments were developed for this study. One instrument targets commissioning providers and the other targets building owners who have participated in a commissioning process or are knowledgeable about commissioning. Both surveys include quantifiable (closed-response questions) as well as open-ended questions. All questions allow for opinions and discussion. Each instrument was presented in draft form to the PG&E project manager for additions and adjustments before testing. The surveys were then tested and modified in-house and fine-tuned after the first interview. The survey instruments are included in Appendix B.

During testing, each survey took about 40 to 45 minutes. This was 10 to 20 minutes longer than desired. Based on PECO's experience, most people resist interview lasting more than 20 minutes, thus the length of each survey was a concern for meeting the goal of 50 surveys within the required time frame. The owners' survey included 48 questions and the providers' survey included 53 questions. After discussions with PG&E about shortening the surveys, it was decided that more in-depth information with fewer surveys was better than several shorter surveys. Therefore, the length of surveys was not altered.

After the survey instruments were developed, the target list of survey participants was compiled based on:

- ✍ Recommendations from Pacific Gas and Electric Company's program managers and staff
- ✍ Recommendations from representatives and stakeholders in the building commissioning sector known to PECO
- ✍ PECO's participant list from past National Building Commissioning Conferences

✍ Recommendations of building owners and operators provided by the commissioning providers interviewed during the provider survey

The provider participant list was crafted to include a variety of commissioning service providers such as independent commissioning consultants, design engineers, architects, testing, adjusting and balancing contractors, and mechanical/electrical engineers. The owner list includes owners or owner representatives from a broad sector of building types such as hospitals, universities, high-rise office buildings, low-rise office buildings, and high-tech/laboratories. The providers' survey was started prior to the owners' survey in order to obtain the names of owners from the providers. This strategy worked well and several names were added to the owners' list.

Once the surveys were completed, the data was entered into a Microsoft Access database. Simple frequency analysis was performed by querying the database for each question and summarizing the results. If questions arose during analysis, follow-up calls were made to the respondents when appropriate to clarify their responses.

Due to the small sample size (49 total respondents) for these surveys, results cannot accurately be generalized to the entire commissioning industry in California. However the results do provide an anecdotal snapshot of the current state of the industry and can be useful for informing PG&E's planning process. The following section reports out the results of the surveys.

Interview Results

The following two sections present the survey findings from interviews with 25 commissioning providers and 24 building owners. Survey results from the commissioning providers (vendors) are presented first. The questions are presented sequentially, followed by a brief discussion of the results. Representative comments by the respondents are included on open-ended questions and responses to questions are tabulated where helpful. Tables are numbered consecutively, and labeled with a “P” for “Provider” or a “C” for “Customer.” In cases where raw data is unwieldy but thought to be interesting, a summary table is included in the body of the report, and a complete breakout of the data is provided in Appendix A.

Provider Interview Results

The following describes the survey findings from interviews with 25 commissioning providers.

Background: Profile of Practitioners

The first six questions sketch a basic profile of the firms interviewed. Over half of the respondents classified their firms primary business as engineering.

Primary Business

[Q1] How would you classify the **primary** business conducted by your firm? (Select all that apply)
n=25

The 25 practitioners surveyed classified their primary business as follows:

- ~~///~~ 13 Engineering Firms
- ~~///~~ 4 Building Commissioning Providers
- ~~///~~ 2 Testing and Balancing Contractors
- ~~///~~ 1 A&E
- ~~///~~ 1 Design Build Contractor
- ~~///~~ 1 Architecture Firm
- ~~///~~ 3 Others (2 energy conservation consultants and 1 controls consultant)

Number of Employees

[Q2] How many people does your firm employ? n=25

Almost half the firms employ ten or fewer people. This includes one quarter of the respondents who are independent consultants, working alone. The largest firm employs 600 people. Table P1 summarizes the firms by number of employees.

Table P1: Size of Firm

Employees	Firms
1 to 10	12
11 to 25	2
26 to 50	5
51+	6

Familiarity With the Term Commissioning

[Q3] Are you familiar with the term commissioning?	n=25
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All respondents are familiar with the term “commissioning.” This is expected since the intention for the survey is to gather information from individuals that have an understanding of the current commissioning market for both new and existing buildings.

New Construction Commissioning Providers

[Q4] Is commissioning for new construction projects a service that you provide?	n=25
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Nineteen of the respondents provide new construction commissioning services, four only provide retrocommissioning services, and two don't provide commissioning services but were interviewed based on their expertise in construction quality control strategies and knowledge of commissioning.

Existing Building Commissioning Providers

[Q5] Is commissioning for existing buildings, which is sometimes called retrocommissioning, a service that you provide?	n=25
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Twenty-one of the respondents provide commissioning services for existing buildings. Two respondents only provide new construction commissioning services, and two of the respondents don't provide any commissioning services, as discussed in Question 4.

Providers' Commissioning History

Questions 6 through 15 address the providers' definitions of commissioning and the extent to which they have been involved in recent commissioning activity. Information was solicited to provide an understanding of the overall commissioning marketplace.

Definition of New Construction Commissioning

[Q6] How do you define building commissioning as it applies to new construction projects?	n=25
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When asked to define commissioning, some providers said the main goal of commissioning is to verify that building performance meets the design intent. These respondents often mentioned functional testing as a method of verifying that the performance standards were met. Only six of the respondents specified that commissioning assists in the **development of proper design** as well as the verification of meeting the design intent.

Definitions of commissioning as verifying performance included:

- ☞☞ “A quality assurance process that ensures the building owner receives a building that performs as designed”
- ☞☞ “Verifying that operation meets design criteria”
- ☞☞ “Ensuring that building systems perform as intended according to the design”

The three broader definitions of commissioning included:

- ☞☞ “A process undertaken from the design phase or earlier through construction to occupancy that ensures the systems are designed, installed and operating according to the design intent documentation”
- ☞☞ “To ensure good design and ensure that construction is properly done by verifying systems operation and functionality in accordance with the design intent”

✍✍“A process that involves peer review, design assistance, enhanced construction scheduling, verification and testing”

Definition of Existing Building Commissioning

[Q7] How do you define commissioning as it applies to existing buildings?	n=25
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When asked to explain their definition of existing building commissioning, one group of providers focused on the testing and tune-up tasks of the project. The other group included “bringing the building back to the original design intent” in their definitions.

The following comments reflect both definitions of existing building commissioning:

✍✍“Assessing the current state of the existing building systems through hands-on testing and tuning”

✍✍“A building tune-up of mechanical electrical and control systems. Correcting the weaknesses and operationally adjusting to improve efficiency”

✍✍“Testing and adjustment of controls while checking other equipment”

✍✍“Making sure that the building operates as designed and that the operating procedures are working optimally”

✍✍“Analyzing the original design intent and then updating the system’s operation to achieve that intent again or change it to meet the current needs of the building”

✍✍“Same as a new construction commissioning process, but more of a building tune-up/optimization process to bring the building back to the original design documentation”

Reasons for Not Providing Commissioning Services

[Q8] If the respondent doesn’t provide any commissioning or retrocommissioning services, ask why. Then skip to question 37	n=2
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Only two of the respondents interviewed do not provide commissioning services. One respondent is a mechanical engineer and spends his time designing mechanical systems, providing design peer review services, and acting as an expert witness in lawsuits. He felt that many commissioning projects included more design review, design coordination, and paperwork than necessary, and that in many cases, owners were paying too much for this service. He emphasized that the selection of a qualified designer appropriate to the project’s complexity would lead to a project with fewer problems.

The other respondent said that he approves of the commissioning process but as a consultant, he is more of “thinker” than a “practitioner” and is not interested in performing day-to-day commissioning tasks. Because these two respondents do not provide commissioning services directly they were not asked questions nine through thirty-nine.

Annual Number of Commissioning Projects

[Q9] Please indicate the average number of commissioning projects (by type) performed yearly by your firm over the last 2 to 3 years.	n=23
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Only 20 out of the 23 providers were able to give square footage estimates. Renovations and equipment change-outs accounted for forty percent of the estimated projects, the largest single block of projects. New construction commissioning of **specific systems** accounted for 25% of

projects, almost double the percent of new construction projects with **all** systems commissioned. Table P2 summarizes the providers' responses.

Table P2: Estimated Annual Commissioning Projects in California

Type of Project	# of Projects	# of Square Feet
<i>New construction: All building systems commissioning</i>	<i>23</i>	<i>8,040,000</i>
<i>New construction: Specific systems commissioning</i>	<i>36</i>	<i>4,740,000</i>
<i>Renovation or equipment change out</i>	<i>88</i>	<i>15,575,000</i>
<i>Retrocommissioning of existing building equipment</i>	<i>44</i>	<i>2,535,000</i>

When we look at the size of the firm based on the **total** number of employees (Question 2) and compare that to their annual square footage of all commissioning work (Question 9) we find that smaller firms account for more commissioning than larger firms. Table P2.1 shows the estimated average square footage commissioned annually by each firm over the last three years. The firms are sorted by the total number of employees, from small to large. Out of approximately 32 million square feet commissioned annually, the smaller firms (ten employees or fewer) reported 19.5 million square feet, or 60% of the total square footage commissioned. Although there is not a clear correlation between smaller firms and more commissioning activity, the single firm that accounted for almost half of all commissioning is a firm with five employees. (We verified this result with a second call to the provider. He confirmed his original estimate of 13 million square feet commissioned annually.) However, he works almost exclusively with commissioning new equipment for renovations (see table P2.1 survey number 107).

Table P2.1: Average Annual Square Footage Commissioned

Survey #	Type of Firm	Employees	Square Feet: New* Commissioning	Square Feet: Retrocommissioni ng	Total Annual Square Feet
106	Engineering	1	0	45,000	45,000
112	Engineering	1	175,000	50,000	225,000
123	Commissioning	1	Don't know (DK)	DK	DK
116	Engineering	1	2,250,000	0	2,250,000
102	Commissioning	2	300,000	0	300,000
101	Engineering	4	DK	DK	DK
124	Commissioning	4	DK	DK	DK
107	Engineering	5	13,000,000	500,000	15,000,000
122	Engineering	7	160,000	0	160,000
120	Engineering	8	1,550,000	0	1,550,000
117	Controls Contractor	16	DK	DK	DK
121	Engineering	22	1,600,000	200,000	1,800,000
103	Commissioning	30	320,000	240,000	580,000
119	Design/Build	35	500,000	0	500,000
114	Commissioning	35	1,000,000	500,000	1,500,000
113	Engineering	40	600,000	200,000	800,000
108	Energy Consultant	40	300,000	800,000	1,100,000
111	Commissioning	52	0	DK	DK
109	Engineering	80	5,400,000	0	5,400,000
118	Architecture	90	400,000	0	400,000
105	Engineering	150	800,000	0	800,000
110	Engineering	320	DK	DK	DK
125	Engineering	600	DK	DK	DK
Totals			28,355,000	2,535,000	32,390,000

*New commissioning includes commissioning of all systems, specific systems, and renovations.

Who Contracts for Commissioning Services

[Q10] Who contracts with you for your commissioning services? (Check all that apply) n=23

Because many of these providers have worked on more than one commissioning project, multiple responses were typical. Almost all providers said that they have been contracted by the building owner directly on at least one project. Roughly half the providers indicated that they have been hired

by the general contractor. Design engineers and construction managers were each designated by one quarter of the respondents. Their responses are shown in Table P3.

Table P3: Who Contracts for Commissioning Services

Who Contracts?	Responses
<i>Building owner, directly</i>	<i>21</i>
<i>The architect</i>	<i>2</i>
<i>The general contractor</i>	<i>10</i>
<i>The mechanical/electrical engineer</i>	<i>5</i>
<i>The construction manager</i>	<i>5</i>
<i>Utility</i>	<i>1</i>
<i>Don't know</i>	<i>1</i>
<i>Other*</i>	<i>3</i>

*“Other” included attorneys, energy service companies (ESCO’s) and property management firms.

Employees Who Perform Commissioning Services

[Q11] How many employees in your firm currently perform commissioning services?	n=23
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Although half the firms providing commissioning services employ more than ten people (see Question 2), almost 80% of the firms have 10 or fewer employees actually performing the commissioning tasks. The number of employees engaged in commissioning services is shown in Table P4.

Table P4: Employees Engaged in Commissioning

Employees Performing Commissioning	Firms
<i>0 to 5</i>	<i>15</i>
<i>6 to 10</i>	<i>3</i>
<i>11 to 25</i>	<i>4</i>
<i>26+</i>	<i>1</i>

Commissioning as a Percentage of Overall Business

[Q12] What percentage of your business is made up of commissioning services?	n=23
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Most firms claim that less than half their business is commissioning related. This is expected, as many firms, especially larger ones, offer diverse services and have not found enough demand to rely exclusively on commissioning services for their revenue. When we sorted the firms according to size (number of employees), we found that firms specializing in commissioning tend to be smaller. The largest firm with significant commissioning activity was a firm of 35 employees. Table P5.1 in Appendix A shows the firms sorted by size and the percentage of their business that is

commissioning. A summary of provider responses in the table below shows that over half the firms say commissioning accounts for 10% or less of their business.

Table P5: Commissioning as a Percentage of Business

Percentage of business that is commissioning	Firms
<i>1% to 10%</i>	<i>12</i>
<i>11% to 25%</i>	<i>3</i>
<i>26% to 50%</i>	<i>4</i>
<i>51% +</i>	<i>4</i>

Building Commissioning in Your Mix of Business Services

[Q13] How do you classify building commissioning in the mix of business services and products that you provide to your customers?	n=23
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Almost half of the respondents classify commissioning as part of their core business, provided as a basic service. Table P6 illustrates these results.

Table P6: Commissioning As Part of Business Services

Classification of Commissioning within Mix of Services	Firms
<i>Integral component to core business, provided as a basic service</i>	<i>10</i>
<i>Integral component to core business, provided as a differentiated service</i>	<i>5</i>
<i>Separate component from core business, provided upon request</i>	<i>8</i>

Past Commissioning Services

[Q14] How long has your firm offered formal commissioning services?	n=23
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Although the word commissioning and various commissioning type activities are not new to the engineering/construction industry, it is only over the last decade that it has emerged as a discrete market. It is therefore not surprising that two thirds of respondents have offered the service for ten years or less. The rest say they have offered commissioning for the past 11 to 25 years, with the exception of one design-build firm who claims to have been performing commissioning for 38 years. The distribution of firms is summarized in Table P7.

Table P7: Length of Experience

Years Offering Formal Commissioning Services	Firms
<i>1 to 5 years</i>	<i>7</i>
<i>6 to 10 years</i>	<i>8</i>
<i>11 to 25 years</i>	<i>7</i>
<i>26+ years</i>	<i>1</i>

Commissioning in Various Sectors

[Q15] For what sectors have you provided commissioning services? (Check all that apply) n=23

Responses indicate that firms are commissioning a wide range of building types. At least half the providers indicated that they provide commissioning services for each type of building, with the exception of the Cold Storage/Supermarket sector. Table P8 shows the number of firms that provide commissioning for each type of building.

Table P8: Building Types Commissioned

Building Type	Firms
High-rise Offices (3+ Stories)	18
Low-rise Offices (<3 Stories)	17
Hospitals	14
Laboratories/Cleanrooms/Research facilities	17
Universities	14
K-12 schools	11
Government facilities	16
Supermarkets/Cold Storage	5
Other	11

Many of the providers said that commissioning is more likely to be included in projects where the owner emphasizes environmental or building quality. “Other” responses included libraries, museums, sports arenas, central plants, data centers, prisons, and historic buildings.

The Commissioning Process

The next group of questions discusses the process of commissioning itself: the stages of implementation and routine activities performed by the providers.

Beginning the Commissioning Process

[Q16] At what stage of the construction process do you **typically** begin providing commissioning services? (Check one) n=20

Only 20 of the 25 people interviewed answered this question. In addition to the two interviewees that do not provide any commissioning services, three others claimed that this question was not applicable to them because they primarily provide retrocommissioning services. One provider who primarily provides retrocommissioning services chose to answer this question based on their minimal experience with new building commissioning. Table P9 shows that roughly half the

respondents begin providing services in the Programming or Design phase, while the rest begin at Construction or Warranty. However, given that only six respondents defined “commissioning” as encompassing the design phase (Question 6), we suspect that these results reflect what providers would do in an ideal world, as opposed to what they do in reality.

Table P9: When Commissioning Begins

Phase	Number
<i>Programming Phase</i>	4
<i>Design Phase</i>	7
<i>Construction Phase</i>	7
<i>Warranty Phase</i>	2

Earliest Phase to Ever Include Commissioning

[Q17] What has been the earliest phase that you have begun a commissioning process?	n=23
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Some respondents stated that on at least one project they had included commissioning earlier than what was **typical** (see Q16 for when commissioning typically begins). Slightly less than half the respondents have ever begun commissioning in the pre-design phase. Most of them have started in the design phase or earlier, at least once. The variation between the typical and the earliest phases of commissioning indicate that commissioning is not yet recognized as process that can be integrated into all phases of the construction process.

Table P10: Earliest Phase of Commissioning

Earliest Phase	Number
<i>Programming Phase (pre-design)</i>	10
<i>Design Phase</i>	8
<i>Construction/Installation</i>	1
<i>Warranty Phase</i>	2

Bidding and Negotiating for Commissioning Services

[Q18] How does your firm handle bidding/negotiating for commissioning services?	n=22
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Several respondents use more than one method of bidding. Over half the respondents handle bidding for commissioning services as a separate contract. Slightly less than half have treated commissioning services as a separate line item. Table P11 shows all the responses.

Table P11: Negotiating for Commissioning Services

Bidding/Negotiating	Number
<i>As a separate line item</i>	<i>10</i>
<i>As part of the standard service fee</i>	<i>6</i>
<i>Separate contract</i>	<i>12</i>
<i>Other*</i>	<i>1</i>

*Subcontracts at an hourly rate

Cost Estimating

[Q19] What is your typical method for developing cost estimates for commissioning services? n=23

Over 80% of the providers typically use an hourly breakdown for estimating costs. Some providers use different methods for estimating costs depending on project type, size and complexity. Table P12 shows their methods.

Table P12: Cost Estimating

Method of Estimating Costs	Number
<i>\$ per square foot</i>	<i>2</i>
<i>% of construction costs</i>	<i>3</i>
<i>% of mechanical costs</i>	<i>1</i>
<i>% of electrical costs</i>	<i>1</i>
<i>% of system costs</i>	<i>1</i>
<i>Contingency fee</i>	<i>0</i>
<i>Hourly breakdown cost estimate by task or piece of equipment</i>	<i>19</i>
<i>Other*</i>	<i>8</i>

*“Other” included a computerized estimation by system and equipment counts (1) or a combination of these choices, depending on the scope of the project and number of control points (7).

Routine Commissioning Activities

[Q20] I will list a number of commissioning activities. Please indicate which ones are routinely part of your firm’s commissioning process for new construction projects. n=22

All respondents conduct or oversee equipment functional tests. All but one document sequence of operation and all but one develop functional test protocols. Other activities, especially in the design phase, are less prevalent; less than 60% of respondents develop full design intent documentation or conduct a commissioning focused design review. These results indicate that construction and warranty phase commissioning projects are most typical. Surprisingly, 35% of respondents verify

code compliance. It is encouraging to note that 20 of the 22 respondents say they routinely verify operator training. Table P13 shows the distribution of routine commissioning activities.

Table P13: Routine Commissioning Activities

Commissioning Activity	Yes	No	(1 Don't Know)
<i>Documenting design decisions/criteria during programming</i>	11	11	
<i>Commissioning-focused design review</i>	12	9	
<i>Developing full design intent documentation</i>	13	9	
<i>Verifying code compliance during design</i>	8	14	
<i>Developing system performance standards</i>	18	4	
<i>Developing a comprehensive commissioning plan</i>	19	3	
<i>Documenting sequence of operation</i>	21	1	
<i>Developing functional test protocols</i>	21	1	
<i>Conducting/ or overseeing equipment functional tests</i>	22	0	
<i>Verifying operator training</i>	20	2	
<i>Performing operator training</i>	13	9	
<i>Approving O&M manuals</i>	19	2	
<i>Developing a preventive maintenance program</i>	6	16	
<i>Other activities not mentioned</i>	7		

Other activities included:

- ~~///~~ Reviewing equipment submittals
- ~~///~~ Conducting job site meetings and walk-throughs
- ~~///~~ Reviewing control system programming
- ~~///~~ Tuning the system for maximum energy efficiency
- ~~///~~ Providing electronic O&M manuals

Documentation and Tools for Commissioning

Questions 21 through 26 address the specific documents and tools that providers use in the commissioning process.

Documentation Routinely Developed

<p>[Q21] When you are involved in commissioning a project, which types of documentation do you routinely develop?</p>	n=23
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Almost all of the respondents indicated that verification checklists, functional tests, and final reports are routinely developed as part of their commissioning projects. Two-thirds develop design intent documentation. Less than half document energy or cost savings estimates. Table P14 shows the routine documentation developed by the providers.

Table P14: Documentation

Documentation	Number
<i>Contract language</i>	12
<i>Bid specifications containing commissioning requirements & procedures</i>	15
<i>Design intent documentation</i>	16
<i>Prefunctional or verification checklists</i>	21
<i>Functional tests</i>	22
<i>Commissioning final report</i>	22
<i>Systems manual or enhanced operation and maintenance manuals</i>	14
<i>Track or document estimated savings</i>	10

These results may reflect the providers' primary occupations. Contractors and testing and balancing specialists are typically not part of the design process, so they would not document design intent as part of their commissioning work.

Tasks Not Requested by the Client

[Q22] Are there tasks that you routinely do as part of the commissioning process that you are not asked to do by your client? n=23

Half the respondents indicated that they routinely do tasks they are not asked to do by their clients. However, many of the tasks cited are considered part of standard commissioning, so the fact that owners haven't requested them is merely evidence that owners do not know what to expect of commissioning providers. Many of the tasks performed entail overall system tuning or equipment calibration.

Respondents perform the following standard activities without client request:

- ☒ Documentation of site visits and sitting in on meetings
- ☒ Cost estimating of savings potential
- ☒ Short term diagnostics with dataloggers
- ☒ Extra system tuning to make the individual pieces function better within the integrated system
- ☒ System tuning and follow up for 6 months to a year after

Respondents also perform several value-added activities without client request:

- ☒ High level of detail in calibrating equipment
- ☒ "Real" value engineering (adding quality and long-term benefits)
- ☒ Verification of fault procedures
- ☒ Refereeing contractor disputes

Resources, Tools and Documents Used In Commissioning

[Q23] What resources does your firm use in the commissioning process? (Check all that apply) n=23

Almost 90% of respondents indicated that having a guideline to help them through the process, especially on their first commissioning project, was very valuable. They also indicated that measuring

devices, data loggers and especially the energy management control system were very important in determining whether equipment was performing in accordance with the design intent. It was not ascertained as to whether vendors calibrated and commissioned the EMS before using it as a data gathering tool. Table P15 shows the providers' responses.

Table P15: Resources, Tools and Documents Used in Commissioning

Tool	Number
<i>Performance assessment tools and analysis software</i>	10
<i>Commissioning guidelines</i>	20
<i>Test libraries</i>	9
<i>Portable data loggers</i>	18
<i>Long-term monitoring</i>	10
<i>Sample specifications</i>	15
<i>Handheld measuring devices (thermometers, ammeters, flow hoods, light meters, etc.)</i>	22
<i>Your own tools-(Please specify)</i>	15
<i>Energy management system</i>	19

When asked about their own tools, many respondents indicated that they were using their own internal spreadsheets and databases to assist them.

Specific Tools Used

[Q24] Of the items you listed, could you please tell us what **specific** items or tools you are using?

Most respondents discussed “hardware” tools. In particular, some providers mentioned tools to test equipment used in environments with very tight airflow or temperature parameters such as cleanrooms or pharmaceutical labs. Tools cited were:

- ✍ Shortridge flow meters (2)
- ✍ Fluke power meters (2)
- ✍ CO₂ measuring devices (1)
- ✍ Trace gas analyzers (1)
- ✍ Cleanroom particle counters (1)
- ✍ Infrared measurement devices (1)
- ✍ Veris (energy auditing) (1)
- ✍ Dataloggers: Hobo from Onset (4) Avatel, AEC, ACR (3)
- ✍ PACRAT and KC Tools software (1)

Usefulness of Tools

[Q25] Which of these tools have you found most useful and why?

The single most valued tool is the EMCS, specifically mentioned by eight respondents for its trending capability. Many respondents also valued the various testing devices such as voltmeters, velometers, and dataloggers. One respondent wished to compliment PG&E for its extensive tool lending library and another respondent hoped that PG&E would add Shortridge airflow instruments to the library at some point in the future.

Comments on the usefulness of various tools included:

- ✍✍ “It depends on situations in which the tools are used; flow hoods, hot wire ammeters, pressure chart recorders and temperature capturing devices are all useful.”
- ✍✍ “EMCS - for its trending capabilities”
- ✍✍ “The velometer is very helpful in determining air velocities”
- ✍✍ “Shortridge - for all the different airflow analysis tasks it can do”
- ✍✍ “Trend logs from the EMCS that can then be converted into curves for incorporation into the final commissioning report”
- ✍✍ “Software tools such as PACRAT and KC tools to help reduce the time spent on project management and increase the time spent on functional testing”

Documents

[Q26] Have you used any of the following documents to assist you in developing your commissioning services? (Check all that apply)

n=23

More than two-thirds of the respondents indicated that they had used either the 1989 or 1996 version of ASHRAE Guideline 1 at some point to help them develop commissioning services. The US DOE Model Commissioning Guide Spec. was the second most popular document, used by almost half of those surveyed. The documents used are tallied in Table P16.

Table P16: Documents Used in Commissioning

Guideline	Number
<i>ASHRAE Guideline 1-1989: Commissioning of HVAC Systems</i>	16
<i>ASHRAE Guideline 1-1996: The HVAC Commissioning Process</i>	17
<i>Building Commissioning Guidelines – Bonneville</i>	6
<i>NEBB, "Procedural Standards for Building System Commissioning"</i>	9
<i>Commissioning of Heating, Ventilating, and Air-Conditioning systems Guide Specification – Air Force/Army/Navy</i>	1
<i>Montgomery County Commissioning Guideline</i>	2
<i>U.S. DOE Model Commissioning Guide Spec</i>	10
<i>NIST HVAC Functional Inspection and Testing Guide</i>	3
<i>Guide for Commissioning Existing Buildings – Oak Ridge National Laboratory</i>	4
<i>Others</i>	14

The “Other” documents mentioned were:

- ~~///~~ SMACNA “HVAC Commissioning Guidelines” (4 responses)
- ~~///~~ PECO documents (3)
- ~~///~~ LEED documents (3)
- ~~///~~ University of Washington’s “Facilities Services Design Information Guide” (2)
- ~~///~~ AABC (Associated Air Balance Council) documents (1)
- ~~///~~ NCBC Proceedings (1)
- ~~///~~ NETA documents (1)
- ~~///~~ Southern California Edison Envest Commissioning Guidebook (1)

The Changing California Market: Provider Opinions

The following questions elicit provider attitudes and opinions about the current and future market for commissioning in California. Providers shared their opinions on both the quality and the quantity of current commissioning activity.

Percentage of New Construction Projects That Include Commissioning

[Q27] In your opinion, what percent of new construction projects in California include commissioning?	n=23
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Providers responded with a broad range of estimates on how much new construction commissioning is taking place in California. They estimated that anywhere from 0.5% to 30% of new projects include commissioning. The majority of those who gave an estimate thought that commissioning was included in less than 11% of new projects. Table P17 shows their response.

Table P17: Estimates of Commissioning Activity

% of New Construction Projects that Include Commissioning	Responses
<i>0-2%</i>	<i>5</i>
<i>3-5%</i>	<i>4</i>
<i>6-10%</i>	<i>5</i>
<i>11-50%</i>	<i>4</i>
<i>Don't Know</i>	<i>5</i>

Percentage of Existing Buildings That Have Been Retrocommissioned

[Q28] In your opinion, what percent of existing buildings in California have gone through retrocommissioning? n=23

These responses are higher than expected, with the majority estimating that over 10% of the buildings have gone through a retrocommissioning process. Considering the estimates they gave regarding their own retrocommissioning projects compared to their new commissioning projects (Q9), their opinions are questionable. In question nine they estimated four times as many new commissioning projects as retrocommissioning projects. Although all participants heard a definition of retrocommissioning at the beginning of the survey, it appears that they may have regressed back to the typical “energy conservation project that often includes O&M measures” when responding to this question. Table P18 shows their response.

Table P18: Buildings Retrocommissioned

% of Buildings Retrocommissioned	Responses
<i>0-10%</i>	<i>5</i>
<i>11 to 25%</i>	<i>10</i>
<i>26 to 50%</i>	<i>5</i>
<i>Over 50%</i>	<i>0</i>
<i>Don't Know</i>	<i>3</i>

A Changing Market

[Q29] In your opinion, do you think the market for commissioning services is: Increasing Significantly, Increasing Slightly, Stable, Decreasing Slightly, or Decreasing Significantly? n=23

Over 90% of the providers feel that the commissioning market is increasing with 60% believing the market is only increasing slightly. None of the respondents feel the market is decreasing. Their responses are presented in Table P19.

Table P19: Change in Market Demand for Commissioning

Change	Responses
<i>Increasing significantly</i>	8
<i>Increasing slightly</i>	13
<i>Stable</i>	2
<i>Decreasing slightly</i>	0
<i>Decreasing significantly</i>	0

Reasons for the Increase

[Q30, 31] If Commissioning is increasing, rank the following reasons for this increase in order of importance. If decreasing, why do you think this is occurring? n=22

As a follow up to Question 29, providers were given a list of reasons why the market was increasing and asked to rate them. Over two-thirds of providers rated “increased owner awareness” as a highly important reason for the increase in market demand. Providers split over “changes in the utility industry,” with ten ranking this of low importance and twelve ranking this of medium or high importance. Notably, providers do **not** attribute the increase in commissioning business to the overall growth in the building industry. Over two-thirds of respondents said that total market growth was of little import to the increase in commissioning. Table P20 shows their ratings.

Table P20: Reasons for Increase in Commissioning

Reason	Low	Medium	High
<i>Growth in total market for building construction and renovation</i>	16	3	3
<i>Increased owner awareness and requests</i>	1	6	15
<i>Changes in the electric utility industry</i>	10	9	3
<i>Concern for professional liability</i>	18	4	0

Providers observed that greater awareness about IAQ, energy usage, and tenant comfort has made owners request better performing facilities. No providers believe that the market for commissioning services is decreasing. However, one provider cautioned that the industry is at a crucial turning point. Without proper oversight and quality assurance, the commissioning industry could fail if practitioners provide poor service in the rush to enter the marketplace. Comments on the increase in commissioning included the following:

- ✍️“Programs like LEED have increased awareness on the productivity of workspace associated with IAQ and comfort.”
- ✍️“Internet based tools and the computer industry have evolved to the point that owners and managers can more easily access building data and use it to see the value in retrocommissioning services.”
- ✍️“The overall complexity of [building] systems necessitates commissioning.”
- ✍️“Design/build buildings are failing.”
- ✍️“Owners are fed up with non-performance of their buildings.”

“Energy costs are increasing and the owners want to know they got what they paid for.”

Perceived Benefits

[Q32] In your opinion, what do **owners** perceive as the greatest benefit(s) of commissioning?
(Unprompted) n=23

Two-thirds of respondents mentioned that owners see operational efficiency as one of the greatest benefits of commissioning. Approximately half mentioned building quality/comfort, and over one-third mentioned energy savings as one of the greatest benefits. When owners were asked a similar question (Q18 in the owners’ survey) they cited benefits relating to the commissioning process with only one respondent mentioning energy savings as the most valuable benefit. Table P21 details the providers’ assessment of owners’ perceptions.

Table P21: Providers’ Opinion of Benefits Perceived by Owners

Benefit	Responses
<i>Reduction in construction costs/less call back</i>	3
<i>Energy savings</i>	9
<i>Operational efficiency</i>	15
<i>Building quality and comfort</i>	11
<i>Longevity and reliability of equipment</i>	1
<i>Indoor air quality</i>	2
<i>Smoother turnover</i>	4
<i>Other: (please describe)</i>	15

Over half of the “other” responses pointed to the general benefit of verifying that owners get what they pay for. Specific responses included: Verification of design intent, proper system selection and application, documentation of systems, identification of problems during design review and higher baseline building. One respondent mentioned litigation avoidance.

Satisfaction With the Current Commissioning Marketplace

[Q33] Are you satisfied with the current state of the commissioning marketplace? n=23

Four-fifths of providers are not satisfied with the current state of the market. Of these, the majority are dissatisfied by the lack of owner awareness of the benefits of commissioning. Another one-third are unhappy with the lack of consistency among providers, as it may give commissioning a bad name. Providers made the following comments:

Regarding the need for more owner awareness:

“There has to be a paradigm shift in owners to understand that they don’t get everything for nothing.”

“Owners don’t see the value or are uneducated.”

“Many owners look at the cost associated with full commissioning and turn it down.”

- ✍️ “There needs to be more awareness of what building commissioning can do for a building and how the benefits are far greater than the costs to have it done.”
- On the lack of consistency among providers:
- ✍️ “[There are] contractors who say they are providers of commissioning services but they really are not performing true commissioning.”
- ✍️ “People are driving down the cost with compromises in quality. Shyster commissioning providers in the market don’t provide real commissioning.”
- ✍️ “Poor implementation has led to questioning of whether the expense is worth it.”

Methods of Improving the Quality of Commissioning

[Q34] Please rate the following strategies for increasing the quality of commissioning services. n=23

Almost two-thirds of providers rated “standardization of commissioning requirements” as very or most effective for increasing the quality of commissioning. This was followed by “certification requirements for commissioning authorities” and “standardization of system testing protocols,” which were rated very or most effective by a majority of providers. A majority of respondents rated “commissioning as a requirement in the four year college engineering curriculum” as only somewhat or not at all effective. Table P22 shows provider ratings of strategies to improve commissioning quality.

Table P22: Strategies for Improving Commissioning Quality

Strategy	Not at all	Somewhat	Effective	Very	Most
<i>Certification requirements for commissioning authorities</i>	6	0	5	9	3
<i>Commissioning as a requirement in the four year college engineering curriculum</i>	5	7	6	3	2
<i>Professional continuing education requirements</i>	3	3	6	7	4
<i>A professional association just for commissioning providers</i>	5	3	4	8	3
<i>Standardization of commissioning requirements</i>	2	4	3	7	7
<i>Standardization of system testing protocols</i>	2	3	6	9	3
<i>Other:</i>					

Other strategies for improving commissioning quality included:

- ✍️ Improving the knowledge of commissioning by other construction trades
- ✍️ Penalizing contractors for non-compliance with commissioning requirements
- ✍️ More hands-on functional test training for providers

The proposal to certify providers as a method of improving commissioning quality elicited mixed reactions. While over half felt that it would be of some benefit, others brought up examples of professional certification programs in other trades that give out membership without comprehensive

testing to ensure competency. Some, while supportive of concept of certification, questioned who would do the certifying and how the certification could occur since the definition of commissioning varies so widely.

In general, many of the respondents were not opposed to a brief exposure to commissioning in college, but felt that most real learning takes place in the field. The majority of respondents indicated that continuing education and professional associations could improve quality, yet they raised some of the same legitimacy concerns they had expressed about certification requirements.

Cost Effectiveness of Commissioning

[Q35] Do you think that commissioning services are cost effective? If so, why?	n=23
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Ninety-five percent of the respondents believe that commissioning can be cost effective. Most of the providers believe that a properly commissioned building will save substantial amounts of energy over its lifecycle. They also cited a smoother construction process, better productivity by building occupants, and fewer problems after the building is completed. Interestingly, one respondent felt that commissioning new construction projects is not cost effective, due to contractor resistance to the process. This resistance consumes the commissioning provider's time and the provider passes these costs through to the building owner in the form of higher commissioning fees. Some representative comments on cost effectiveness include:

- ☞☞“Commissioning lowers energy and maintenance costs, and improves worker productivity.”
- ☞☞“For retrocommissioning projects, energy conservation payback is very attractive.”
- ☞☞“A chiller at the University of Southern California had a couple of month's data before retrocommissioning and the day they reprogrammed it, there was an 11% drop in energy usage.”
- ☞☞“How much does it cost building owners if they **don't** commission their projects? It's essentially a low cost insurance policy.”
- ☞☞“Fewer engineers are needed on the payroll to operate a building that is set up on an EMS system that is highly automated.”

Improvement of Cost Effectiveness

[Q36] How can cost effectiveness be improved?	n=23
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Providers restated many of the same opinions they mentioned in previous answers. In sum, both the building owners and the designers and contractors need to be better educated about the benefits of commissioning. Once they understand the benefits, they will work harder to facilitate commissioning. As more commissioning projects take place, providers will realize economies of scale, ultimately reducing commissioning costs. One provider emphasized that standardization of commissioning requirements would aid in facilitating this.

Providers differ over whether cost effectiveness can be improved by beginning the process earlier and emphasizing design review. Selected providers believe that a detailed design review process is the most cost-effective way to commission a building. Others feel that reducing documentation requirements and emphasizing system testing ultimately leads to more savings. Representative comments include:

- ☞☞“By standardizing the commissioning requirements and testing protocols it will take less time to coordinate commissioning and cut down on expenses.”

- ✍✍ “More commissioning needs to be done.”
- ✍✍ “Train contractors so they can understand the commissioning process and make it work.”
- ✍✍ “Start as early in design as you can.”
- ✍✍ “Reduce commissioning budget amount spent on design review and increase amounts on functional testing.”
- ✍✍ “Choose the appropriate level of commissioning based on the complexity of the project.”

Drivers for Participation and Perceived Market Barriers

The following questions address the motivations of commissioning practitioners and perceived market barriers to increasing the amount of commissioning activity in California.

Motivations for Offering Commissioning

[Q37] Why did you first begin to offer commissioning services? (Prompted)	n=23
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Some providers selected multiple responses to this question. Approximately one third of responses fall into the "project quality assurance" category followed closely by "owners requesting the service." Responses are tallied in Table P23.

Table P23: Reasons for First Offering Commissioning

Reason	Responses
<i>Owner request</i>	8
<i>Electric utility recommendation/requirement</i>	1
<i>Business need/opportunity</i>	5
<i>Project quality assurance</i>	9
<i>Other:</i>	9

Other comments included four cases where a strong personal interest guided their pursuit of commissioning. Providers also said:

- ✍✍ "Everyone expected commissioning tasks for nothing, so we developed a specification for it and put it into our contracts"
- ✍✍ "Litigation"
- ✍✍ "I had been brought into a building for a rebate program which subsequently led to full retrocommissioning after discovering many problems"

Benefits of Commissioning

[Q38] Can you tell me what you think the benefits of commissioning are? (Unprompted)	n=22
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Unprompted, a majority of the providers chose greater energy efficiency and reduced operation and maintenance expenses as the benefits of commissioning. For convenience, their responses are distilled and presented in Table P24.

Table P24: Benefits of Commissioning

Benefits	Number
<i>Fewer contractor call-backs</i>	5
<i>Fewer warranty claims</i>	4
<i>Less litigation involving occupants, designers or contractors</i>	4
<i>Fewer building operator complaints</i>	3
<i>Fewer occupant complaints</i>	9
<i>Takes less time to get system up and running optimally</i>	5
<i>Fewer post-acceptance operational deficiencies</i>	10
<i>More complete/higher quality operations and maintenance manuals</i>	3
<i>Greater energy efficiency</i>	14
<i>Increased equipment lifetime</i>	7
<i>Reduced operations and maintenance expenses</i>	11
<i>Increase productivity for building occupants</i>	5
<i>Others</i>	13

Other benefits mentioned were:

- ✍ Improved indoor air quality (2 responses)
- ✍ Smoother turnover (4)
- ✍ Better construction value (3)
- ✍ Better operator training (4)

Significant Barriers to Incorporating Commissioning Into Your Business

[Q39] What are (or have been) the most significant barriers to your firm incorporating commissioning into your standard business offerings? (Unprompted)	n=24
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The most significant barrier identified was owner ignorance. Most providers believe that building owners do not really understand commissioning. Owners think they are already getting commissioning in their normal construction process, so they don't see the value of for paying more for it. Providers offered these comments:

- ✍✍ “When we offer a full commissioning plan, the fee is so high the owner doesn't want to bid because they are uneducated on the benefits or may have another bid from a so-called provider that is not actually providing commissioning.”
- ✍✍ “The owner thinks they are getting commissioning from their construction manager.”
- ✍✍ “The way it is approached, many customers are scared away by the first costs of commissioning since the savings are difficult to guarantee.”

- ✍️ “Lack of time, today’s tight construction schedules, and owners still not convinced of its benefits.”
- ✍️ “The first cost driven mentality of many owners.”

Other Barriers

[Q40] Do you feel the following are also barriers? (Prompted) n=17

Over 80% of the respondents consider “clients not requesting the service” as the most significant barrier. This echoes their perception that owners’ lack of understanding of commissioning is a major barrier to making it part of standard business practice. One third of respondents admitted that their firm could use more training in commissioning practices.

Table P25: Other Barriers to Commissioning

Barriers	Number
<i>Your current fees don't cover the cost to include commissioning</i>	5
<i>Clients do not request commissioning services</i>	14
<i>Members of your firm are conflicted about the value of commissioning</i>	1
<i>Your firm needs more information about the benefits of commissioning</i>	0
<i>Your firm needs more training/expertise in commissioning practices</i>	6
<i>Your firm lacks the tools/documentation to implement a viable commissioning service</i>	1
<i>Other</i>	0

Tools to Provide Better Commissioning Services

[Q41] What types of tools (process management/diagnostics/analysis) could you use to enable you to provide more complete and efficient commissioning services? n=18

A majority of the respondents want better software tools for diagnostics and analysis, especially tools that can read data from different data logging and EMCS systems. Almost one third of respondents also mentioned process management software to automate and standardize tasks such as estimating commissioning costs. Some providers pointed out that a standardized tool to assist them in planning and bidding a commissioning project would also help building owners better compare the different proposals for commissioning projects. The following are some representative tools suggested:

Tools for diagnostics and analysis:

- ✍️ “The datalogger borrowing program offered by PG&E has been very useful”
- ✍️ A data-handling device that could take data from a number of different control systems
- ✍️ Diagnostics tools that can tie into various EMCS systems
- ✍️ Internet database tool similar to Facility Dynamics tool

Software for process management:

- ✍️ An automated estimating form with checklist costing that comes up with a budget line item based on the commissioning tasks to be accomplished on a project

- ✍ A document control program to streamline the commissioning process between design documentation and functional testing documents
- ✍ An interactive program that allows drawings, O&M materials, and control point sequences to be put on the internet for easier access

Other tools:

- ✍ A simplified line drawing, outlining each commissioning team member's roles and responsibilities

Barriers to New Construction Commissioning

The following two questions ask providers to speak about barriers to commissioning from a building owner's perspective. The intent was to gain perspective on the opinions gathered from building owners in the owners' survey.

[Q42] From a building owner's perspective, what kinds of barriers do you think hinder owners from requesting commissioning services for new construction projects? (Select all that apply) n=23

Most providers point to owners' overall lack of understanding of commissioning, its perceived high costs, and a perceived lack of benefits, as the main barriers to requests for commissioning. Eighty percent cited "Benefits and costs not well understood." Notably, most providers feel that owners have the ability to fund commissioning activities if they wanted to. Less than 10% cited lack of funding as a barrier to commissioning. Interestingly, when owners were asked a similar question (Q43 in the owners' survey), lack of budget followed by perceived high costs of commissioning are cited as their top market barriers. Providers' responses are shown in Table P26.

Table P26: Providers' Perceptions of Owners' Barriers

Barriers	Number
<i>Lack of understanding of what commissioning is</i>	<i>15</i>
<i>The benefits and the costs are not well understood</i>	<i>18</i>
<i>Not knowing who to hire to perform commissioning services</i>	<i>1</i>
<i>A belief that commissioning is part of standard design/construction practices (they already get this service)</i>	<i>9</i>
<i>Perceived added cost of commissioning</i>	<i>13</i>
<i>The lines of responsibility in the design and construction team get confused if an independent agent performs the tests</i>	<i>0</i>
<i>Disruption of construction schedule</i>	<i>2</i>
<i>Lack of certification process for the commissioning providers</i>	<i>0</i>
<i>Can't obtain funding for commissioning</i>	<i>2</i>
<i>Other</i>	<i>6</i>

Other comments on barriers included:

- ✍✍ "If commissioning is not an up front line item in the budget, many contractors will advise against it once the project has started."

- ✍️ “A bad initial commissioning experience”
- ✍️ “Because of quick sale of newly developed properties, many developers don't care about the long-term quality of their projects.”
- ✍️ “Not enough savings-vs.-investment information is available to show owners.”

Barriers to Existing Building Commissioning

[Q43] From a building owner's perspective, what kinds of barriers do you think hinder owners from requesting commissioning services for their existing buildings? (Unprompted) n=20

Providers continue to emphasize that owners do not understand costs and benefits. Ninety percent responded that the benefits and costs were not well understood and 55% noted a lack of understanding of what retrocommissioning is. Table P27 shows the significant barriers mentioned by providers.

Table P27: Barriers to Owners Requesting Existing Building Commissioning

Barrier	Response
<i>Lack of understanding of what retrocommissioning is</i>	<i>11</i>
<i>Benefits and costs are not well understood</i>	<i>18</i>
<i>Not knowing who to hire to perform retrocommissioning</i>	<i>1</i>
<i>A belief that their O&M staff or service contractors already do this.</i>	<i>2</i>
<i>Lack of standardized retrocommissioning procedures</i>	<i>0</i>
<i>Other</i>	<i>7</i>

“Other” comments on barriers to retrocommissioning include:

- ✍️ “Many owners or building managers must wait for a problem to be apparent before fixing it.”
- ✍️ “Owners don’t want to give the perception that there is a problem with their facilities.”
- ✍️ “Owners acknowledge that their buildings are having problems but don’t wish to tackle all of them at once because of perceived high cost.”

Strategies to Increase Commissioning

Questions 44 through 46 address methods for increasing the quality and quantity of commissioning activities.

Marketplace Changes Necessary to Increase Demand for Commissioning

[Q44] In your opinion, what needs to happen in the marketplace to increase demand for both commissioning and retrocommissioning services? (Unprompted) n=25

Providers expressed two major ways that changes in the marketplace could increase demand for commissioning. First, many providers stressed that education on the benefits of commissioning would ultimately increase demand for projects. They specifically suggested case studies on successful projects, promotional campaigns, owner education programs on the benefits of commissioning, and provider education on how to incorporate commissioning into a construction project.

Second, providers speculated that if the trend toward low first cost buildings continues, more owners would receive low-performance buildings and grow dissatisfied. As the long-term financial costs of these mistakes become apparent, owners will look for a better way to construct their facilities. This will allow commissioning to emerge as a quality assurance strategy.

Methods for Increasing Demand for Commissioning Services

[Q45] Please rate the following strategies for increasing the demand for commissioning services.
(Prompted) n=25

Almost 90% of respondents rated “Education programs for building owners and their staff” as most effective or very effective. The second most popular strategy was “Case Studies demonstrating benefits of commissioning,” deemed most or very effective by 65% of respondents. Utility financing programs were also seen as most or very effective by 65% of respondents. Table P28 shows the providers’ ranking of strategies.

Table P28: Effectiveness of Strategies for Increasing Demand

Method	Not at all	Somewhat	Effective	Very	Most
Tax credits	1	6	9	4	5
Standardized commissioning procedures	4	5	6	8	2
Standardized commissioning specifications for construction documents	3	2	8	8	4
Certification for commissioning firms	8	1	7	5	4
Case studies that demonstrate benefits of commissioning	1	2	6	6	10
Utility Financing Programs	1	3	5	9	7
Code requirements for commissioning	8	2	3	5	7
Non-financial awards programs such as free publicity in trade journals	6	6	8	2	3
Marketing materials on Cx that you could hand to potential customers	0	4	10	6	5
Education programs explaining commissioning procedures and benefits for building owners and their staff	0	2	1	8	14

This list of strategies generated many reactions:

- ✍ Tax credits were generally viewed as a “carrot” with which to convince owners to commission their buildings. However, some providers felt that owners might not view this as a large enough incentive to risk a new process.
- ✍ Standardization of commissioning procedures and specifications were generally well received but providers expressed caution about who would develop these standards and how this process would be enforced.
- ✍ Certification of commissioning providers got very mixed responses with many providers believing that certification would not be valuable unless high standards were emphasized.
- ✍ Utility financing programs were rated highly effective. Most providers reiterated that owners have come to expect incentives from the utility for energy conservation projects.
- ✍ The suggestion to change the energy code to require commissioning on new construction projects met with very mixed reactions. On one side, providers said that if the code required

it, owners would be forced to commission their buildings and subsequently market demand for commissioning would increase. Other providers deemed this scenario unworkable because of concerns with how this code would be developed and enforced.

Assistance in Developing Commissioning Skills

[Q46] We are also interested in what commissioning service providers like yourself need to help you increase your skills and reputation as commissioning experts for new building commissioning and retrocommissioning. Please rate the following strategies. n=23

Two popular strategies for developing commissioning skills were “Training workshops on performance testing methods” and “Advanced training workshops on design phase commissioning,” rated very useful or most useful by 70% of respondents. Tools for decreasing delivery time were deemed “most effective” by 40% of respondents, but “least” or only “somewhat” effective by 20%. Least useful was informational workshops on how to sell commissioning services. Table P29 shows providers’ ratings of the usefulness of various methods.

Table P29: Usefulness of Methods for Developing Commissioning Skills

Method	Least	Somewhat	Useful	Very	Most
Informational workshops on state-of-the-art commissioning	0	3	6	8	6
Articles in professional trade magazines showcasing cx projects	1	0	8	8	6
Tools to decrease delivery time such as software tools, automated tools, management tracking tools	3	2	4	5	9
Advanced training workshops on design phase commissioning	1	3	3	10	6
Training workshops on performance testing methods	2	1	4	9	7
Comprehensive test libraries	2	4	5	6	6
Informational workshops on how to sell commissioning services	3	4	6	7	2

Implementation and Technical Problems

The final set of questions seeks to identify implementation and technical problems, and strategies for overcoming them.

Process/Implementation Problems

[Q47] What types of process/implementation problems frequently occur on your commissioning projects? n=23

Most providers expressed frustration with the lack of owner involvement during a commissioning project and a lack of cooperation by the contractors. Providers felt that many owners are not committed to the commissioning process. Consequently, providers have little or no leverage with contractors when problems are identified. Numerous providers complained that subcontractors are not ready with equipment or systems when they are scheduled, thus delaying functional testing. Providers also mentioned fast-track construction scheduling and its impact on the proper completion of functional performance testing. On many projects, the providers have difficulty

scheduling the performance tests or they arrive for scheduled performance tests only to find that the equipment is not ready for those tests. Two respondents mentioned a problem unique to retrocommissioning: interacting with disgruntled building tenants.

The providers made the following comments:

- ✍✍“Owner representatives typically do not place this [commissioning] as a high priority”
- ✍✍“Poor construction management doesn’t see the benefits of commissioning or support the process.”
- ✍✍“The contractor is resistant to the process.”
- ✍✍“Contractors not filling out the verification checklist; controls contractor not ready with control sequences.”
- ✍✍“Enforcing compliance! I have no authority.”

Comments specific to retrocommissioning process problems:

- ✍✍“Building occupants don’t know who you are or what you are supposed to be doing so they are leery of your presence in their building.”
- ✍✍“Having to do our work after hours so we don’t disturb tenants.”

Strategies to Rectify Process Implementation Problems

[Q48] What strategies have you used to rectify these problems?	n=23
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Most providers believe that the earlier commissioning is integrated into a project, the easier it is to get buy-in from the construction team, and subsequently identify problems. Having an owner or owner’s representative who is involved throughout the process helps everyone understand its importance. They also believe that tighter bid specifications that clearly explain each contractor’s role and responsibilities in the commissioning process will allow them to better understand and appropriately bid on projects. Above all, the providers expressed that **continual** education of all the team members about the process yields the greatest benefits to them. Providers suggested:

- ✍✍“Get commissioning integrated into the project instead of tacked on.”
- ✍✍“Raise issues early and often. Use regular team meetings to track progress. Hire the facility manager as early as possible.”
- ✍✍“Educate the contractors on the commissioning process.”
- ✍✍“Let people know up front what will be required of them.”
- ✍✍“Hold special meetings to coordinate with the trades.”
- ✍✍“Have very tight specifications so they (contractors) can’t get out of them”
- ✍✍“Have stringent requirements in construction documents on when the commissioning agent should be called for testing. If not ready when the commissioning agent is called, then penalty clauses should be invoked.”

Technical Problems

[Q49] What kinds of technical problems typically occur on your commissioning projects?	n=23
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Providers repeatedly cited two problem areas: scheduling performance tests (actually a process problem) and building controls programming. In addition, providers encounter poorly calibrated sensors and incomplete installations of control components.

Nine providers commented on EMCS problems involving programming and subcontractors. Many of these problems occurred because the EMCS software had not been customized to the project. They made the following observations:

- ✍✍“The EMCS is programmed by copying blocks of software from other jobs”.
- ✍✍“The EMCS software is not compatible with specific equipment or controls.”
- ✍✍“After lengthy optimization, the EMCS reverts to factory default when a power failure occurs.”
- ✍✍“The controls subcontractor lacks the technical ability to program complex EMCS.”

Three providers specifically mentioned sensors and control calibration problems:

Strategies Used to Rectify Technical Problems

[Q50] What strategies have you used to rectify these problems?	n=23
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Providers stressed that tighter specifications within the contract documents and close coordination with the contractors will reduce some of the scheduling problems and facilitate functional testing. To address the EMCS programming problems, some providers carefully review the software code and check the calibration of the sensors prior to beginning the functional testing. They also believe that owners can eliminate many of these problems by hiring a qualified controls contractor who truly understands programming. To rectify these problems on site, providers stressed the need for detailed sequence of operations documentation, faster data links to assist in downloading control data, and above all an adequate amount of time and patience to diagnose and solve these problems. Specific suggestions to address EMCS difficulties included:

- ✍✍“Incorporate better documentation of loop tuning parameters in the [EMCS] program so it can be redone more easily. Also, educate the manufacturers so that they do not design the firmware to automatically go to default settings.”
- ✍✍“Start at the hardware level with point-by-point testing. Then sequence of operation testing will reveal programming problems.”
- ✍✍“Specify the choices of controls contractors that can be used for the job, limiting the selection to only those that they know can perform the work.”

Owner Interview Results

The results of the twenty-four owner interviews are described below. Responses to each question were tallied where applicable and representative comments are shown. Because the survey directed respondents to skip certain sections depending on their experience, the number of respondents varies from section to section and is indicated in the text.

Background: Profile of Owners

The following questions characterize the owners that participated in the survey.

Type of Facilities Owned

[Q1] What types of facilities do you own and operate? (Check all that apply)	n=24
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The respondents own a variety of facilities. The most commonly owned facilities are:

Government Buildings (laboratories, medical centers, courthouses, jails): 14

High Rise Commercial Office: 13

Low Rise Commercial Office: 11

Table C1: Types of Facilities Owned

Type of Facility	Owners
<i>Hospitals</i>	6
<i>Long-term care or skilled nursing facilities</i>	1
<i>High-rise commercial office buildings (3 stories or more)</i>	13
<i>Low-rise commercial office buildings (1 to 2 stories)</i>	11
<i>Laboratories / Cleanrooms/Research facilities</i>	6
<i>Retail stores</i>	2
<i>Government facilities</i>	14
<i>Schools (K-12)</i>	1
<i>University or college</i>	5
<i>Other: Warehouse</i>	1

Recent Activity

[Q2, Q3] Has your company built any new buildings or done any major renovations 100,000 sq. ft. or more in the past five years? What is the total square feet for these?	n=24
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Twenty owners have completed projects over 100,000 square feet in the past five years. The projects ranged from 34,000 square feet to 3,000,000 square feet. Owners estimate they have completed a total of more than 18,730,000 square feet of new or renovated buildings. Table C2 summarizes the distribution of planned renovation. Table C2.1 in Appendix A lists all projects by survey number.

Table C2: Total Square Feet of Renovation Planned

Total Square Feet of Renovation Planned	Response
<i>500,000 or less</i>	<i>5</i>
<i>501,000 - 1,000,000</i>	<i>9</i>
<i>1,000,001 - 2,000,000</i>	<i>2</i>
<i>2,000,001 - 3,000,000</i>	<i>2</i>
<i>Don't know</i>	<i>2</i>

New Construction versus Renovation

[Q4] What is the percentage of new construction vs. renovation projects?

n=20

Half the owners built predominately new projects. One-quarter renovated existing buildings and the balance split their projects between new construction and renovation. Table C3 presents the owners' estimates of new construction versus renovation.

Table C3: New Construction versus Renovation

Project Types	Response
<i>Majority New Construction</i>	<i>12</i>
<i>Majority Renovation</i>	<i>5</i>
<i>Half New, Half Renovation</i>	<i>3</i>

Plans for New Construction

[Q5, Q6] Is your company planning on building anything new within the next five years? If so, how many projects are you planning that are 100,000 sq. ft. or more?

n=24

None of the owners could give exact numbers, but they shared their rough projections of planned new projects. Approximately three-quarters of the owners are planning new construction projects within the next five years. Most of them plan between one and five new projects each. Table C4 summarizes the owners' responses.

Table C4: Planned Projects 100,000 Square Feet or More

Number of Projects Planned	Response
<i>1-5</i>	<i>9</i>
<i>6 - 10</i>	<i>2</i>
<i>Don't Know</i>	<i>6</i>

Square Feet of New Construction Planned

[Q7] What is the approximate total square feet for these planned new construction projects?n=17

New construction plans range from 60,000 square feet to 3,000,000 square feet, with the majority of owners planning over 250,000 square feet. Collectively, owners specified 11,585,000 square feet of new construction plans. Because several owners could not estimate new construction plans, the actual square footage is probably higher. (See Table C5.1 in Appendix A for all responses.) Summary Table C5 shows the distribution of owners' plans by approximate total square feet.

Table C5: New Construction Plans, Square Feet

Total Square Feet for New Construction	Response
<i>Less than 100,000</i>	<i>1</i>
<i>100,000 - 150,000</i>	<i>1</i>
<i>151,000 - 200,000</i>	<i>1</i>
<i>201,000 - 250,000</i>	<i>0</i>
<i>251,000 +</i>	<i>9</i>
<i>Don't Know</i>	<i>5</i>

Plans for Renovation

[Q8, Q9] Is your company planning any major renovations in the next five years? If yes, how many renovation projects 100,000 sq. ft. or more are planned? n=24

Half the owners are planning major renovations in the next five years. Of these, all of them plan between one and five projects.

Table C6: Major Renovation Projects Planned in Next Five Years

Number of Projects	Response
<i>0</i>	<i>11</i>
<i>1</i>	<i>6</i>
<i>2</i>	<i>3</i>
<i>3</i>	<i>0</i>
<i>4</i>	<i>1</i>
<i>Don't Know</i>	<i>3</i>

Square Feet of Renovation

[Q10] What is the approximate total square feet for all of your planned renovations? n=13

Owners' estimates of future renovation ranged from 60,000 square feet to 3,000,000 square feet. Owners collectively specified close to five million square feet of renovation plans. (See Table C7.1 in Appendix A for all responses.)

Table C7: Total Square Feet of Renovation Planned

Approx. Total Square Feet of Renovation Planned	Response
<i>Less than 100,000 Sq. Ft.</i>	<i>2</i>
<i>100,000 – 150,000 Sq. Ft.</i>	<i>2</i>
<i>151,000 – 200,000 Sq. Ft.</i>	<i>3</i>
<i>201,000 – 250,000 Sq. Ft.</i>	<i>1</i>
<i>Over 250,000 Sq. Ft.</i>	<i>5</i>

Commissioning Awareness

Current Quality Assurance Practices

[Q 11] What type of quality assurance strategies do you integrate into your new construction projects to make sure you are getting buildings that perform as designed? (Unprompted) n=23

This question was designed to elicit a picture of current owner quality assurance practices. Our sample contained a number of owners that we knew had experienced commissioning, so it is no surprise that more than half of the respondents referred to commissioning as a quality assurance strategy they use or would like to use. A few said that they use commissioning only on their “larger” projects, although their definition of “larger” varied widely, from 10,000 square feet and greater to 50,000 square feet and greater. Some owners described quality assurance as merely testing systems after installation.

Our survey did not ask owners to specify whether their commissioning process was performed in-house. However, close to 30% of the owners who use commissioning volunteered that they perform some aspects of commissioning in-house. Respondents that did not mention commissioning as a quality assurance method rely on the architect, mechanical engineer, contractor and in-house staff to ensure that the design is implemented successfully. Owner practices are tabulated in Table C8.

Table C8: Owner Quality Assurance Practices

Method		Response
<i>Commissioning mentioned</i>		14
<i>Mentioned performing in-house</i>		4
<i>Mentioned hiring outside provider</i>		5
	<i>Both</i>	1
<i>Other methods (includes in-house staff testing, and overseeing contractor and design drawings)</i>		9

The comments below are typical of respondents who mentioned commissioning:

- ✍✍ “We would like to commission all projects but currently commissioning is done by project management and facility staff.”
- ✍✍ “We complete some form of commissioning, usually during the construction phase.”
- ✍✍ “We do a small part of commissioning; we use all in-house staff.”
- ✍✍ “We try to go with full commissioning, not just performance testing and acceptance testing.”
- ✍✍ “Our internal commissioning process includes extensive design review and weekly team meetings with the construction team during the building process.”

Respondents who did not mention commissioning offered these comments:

- ✍✍ “Quality assurance is maintained through the usual documentation and specifications and the architect is retained during construction to be on site.”
- ✍✍ “We operate all systems in extreme and normal conditions and oversee contractor testing of systems.”
- ✍✍ “Maintenance staff reviews design drawings to point out features that can help them when the building is complete.”
- ✍✍ “The inspector of record advocates for the company and requires each system to operate according to design.”

Building Performance Issues

[Q 12] For your newest buildings, what significant building performance issues have you experienced? (Unprompted)	n=23
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Over thirty percent of the respondents stated that they had experienced problems with their HVAC systems. Some of the problems mentioned include maladjusted VAV boxes, undersized air handlers, and malfunctioning controls that resulted in tenant discomfort or energy waste. Respondents also mentioned building performance issues such as poor design, plumbing and electrical problems, and operator errors. Two owners mentioned the difficulty of trying to hit a moving target, when occupancy exceeds original expectations and IAQ problems result.

The following comments are representative:

- ✍✍ “It is not uncommon for us to have to reset control parameters and sequences of operation.”
- ✍✍ “On most buildings we have HVAC control problems.”
- ✍✍ “Negative pressure caused rain water to seep in through the windows.”
- ✍✍ “Our buildings don’t work as intended. They are energy hogs.”
- ✍✍ “These dot-com companies have a higher occupancy than we designed for.”
- ✍✍ “Contractors not following standards, different equipment being installed and control problems.”
- ✍✍ “Design on two main AHUs was undersized.”
- ✍✍ “Two open-heart surgery rooms [which require cold temperatures] are on the same AHU as the rest of the building so we cool everything and then reheat it.”
- ✍✍ “Design problems, pressures aren’t correct, VAVs not adjusted properly, plumbing and electrical problems.”
- ✍✍ “Design engineer located sensors in a bad place”

Familiarity with Commissioning

[Q13] Are you familiar with the term building commissioning? If so, what does building commissioning mean to you as it applies to a new construction project?	n= 23
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All respondents were familiar with the term “building commissioning.” Approximately three quarters the respondents defined commissioning as primarily the testing of systems. Only two mentioned the ASHRAE definition and only four described a larger process, beginning in design and continuing at least to turnover. The following comments are representative.

- ✍✍ “Performance and diagnostic testing”
- ✍✍ “Vendors performance check systems more thoroughly than normal.”
- ✍✍ “A check of a system’s operations to ensure that they are meeting design intent.”
- ✍✍ “Making sure motors turn in the right direction, pressures are correct, etc.”
- ✍✍ “The inspection, testing, and training process to ensure that a building is built and operated as intended by the design engineer.”
- ✍✍ “Test everything as you bring it on line”
- ✍✍ “Going in with a technical team to make sure the EMS is running as it should”

Commissioning Experience

The next section addresses owners' experience of the commissioning process: the projects completed, the benefits realized, the scope and details of their commissioning, and future plans.

Commissioning Projects Completed

[Q14, Q15] Have any of your buildings or systems ever gone through a commissioning process during construction, retrofit, or a major renovation? If so, how many of your projects have involved some type of commissioning? n= 23

Eighteen owners have gone through a commissioning process. (The other six have only experienced existing building commissioning, or they are in the midst of their first commissioning process.) Almost three-quarters of the respondents who have completed commissioning cited five or fewer projects commissioned. (Notably, two respondents cited over one hundred projects commissioned. In one case, the respondent owns almost 250 buildings and claims he performs in-house commissioning on every renovation and new construction project. The other operates over 200 government laboratories and university facilities, and says he commissions every renovation. They are clearly exceptions to the general pattern.) Summary Table C9 groups the owners by total number of projects completed.

Table C9: Commissioning Projects Completed

Number of Commissioning Projects	Response
1 – 5	13
6-10	3
More than 10	2

Table C9.1 in Appendix A compares the data in Q15 with Q27 to show commissioning projects as a percent of total buildings owned. The table is sorted by survey number. Overall, 9% of buildings owned by our interviewees have been commissioned. This figure includes the high number of commissioning projects cited by the two owners discussed above.

Recent Commissioning Projects

[Q16] Describe your three most recent projects. n=18

Owners described thirty-six different projects, most of them new construction. (Many owners described only one or two projects, as they had not completed three.) Three-quarters of the projects were government owned. Of these, one third were university buildings (labs, classrooms, computer facilities) and two thirds were civic buildings (courthouses, jails, and office buildings.) The privately owned projects were predominately office buildings. An approximate total of 8.5 million square feet were commissioned. Less than one third of respondents could tell us the cost of the commissioning. (Tables C10.1 and C10.2 in Appendix A present all the data for each respondent. Table C10.1 is sorted by building type and Table C10.2 is sorted by survey number.) The responses are summarized in Summary Table C10.

Table C10: Completed Projects by Type

Building Type	Number of Projects	Total Square Feet
<i>Government: University</i>	<i>9</i>	<i>635,000</i>
<i>Other Government</i>	<i>18</i>	<i>5,509,000</i>
<i>Commercial Office</i>	<i>9</i>	<i>2,380,000</i>
<i>Totals:</i>	<i>36</i>	<i>8,524,000</i>

Satisfaction with Commissioning

[Q17] Were you happy with the results from your commissioning project?	n=16
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Three-quarters of respondents were happy with the results, but some of them qualified their response. Two respondents felt that it was too early in their current commissioning process to judge the results. Of the seven who identified areas of dissatisfaction, four had performed internal commissioning and three had hired an independent commissioning provider. Those who completed internal commissioning were not satisfied because:

- ✍ They wanted a full commissioning report (2)
- ✍ Buildings had significant performance or efficiency issues (2)

Those who hired an outside commissioning provider were not satisfied because:

- ✍ The commissioning report was incomplete (1)
- ✍ The commissioning agent was difficult to work with (1)
- ✍ Uncooperative design engineer responsible for the commissioning would not accept the results of the air balancing team (1)

Notable comments from those who were unhappy with the commissioning results:

- ✍✍ “The project manager completed the commissioning activities. We need a commissioning provider. We didn’t get a commissioning report.”
- ✍✍ “There were some holes in the scope of commissioning. At final report time, commissioning of lighting was still incomplete.”
- ✍✍ “Design engineer stubbornness. The air balancing team came up with a problem but the design engineer didn’t want to accept the results.”
- ✍✍ “Service and representation by the Commissioning Agent was frustrating. He was arrogant, but the outcome was OK.”

Perceived Benefits of Commissioning

[Q 18] What did you value most about the commissioning process? (Unprompted)

[Q19] Did you realize any of these benefits? (Prompted)

n=12

Without prompting, most owners cited benefits relating to the process of commissioning, particularly the increased information sharing and communication among designers, owners, and contractors. Representative comments included:

- ✍✍ “The chance to identify deficiencies before the building was occupied.”
- ✍✍ “Information, knowing where you are during construction and having control of what’s being done.”
- ✍✍ “Documentation of everything and increased communication between parties.”
- ✍✍ “The fact that it was done! They verified that the systems work so that when the contractor leaves and the seasons change, you know that it will work.”
- ✍✍ “Separate set of eyes. We got a real world picture of what was going on in the building.”
- ✍✍ “They made suggestions to change (modify) the design to allow for better testing later.”

Aside from the process, many owners revealed that they enjoyed reduced building performance problems. Notably, unprompted only one owner cited increased energy savings as the most valuable benefit. The list below highlights results that owners valued most.

- ✍✍ Reduced construction and warranty issues
- ✍✍ Improved comfort control
- ✍✍ Smoother turnover

When prompted with a list of possible commissioning benefits, most respondents agreed that they had realized most of the benefits. Almost all gained a record of system operation and control sequences. Three-quarters saw smoother turnover, improved comfort control, and reduced O&M issues. Increased energy savings were realized by approximately two-thirds of respondents. Table C11 shows that every benefit on the list was realized by at least half the respondents.

Table C11: Benefits Realized from Commissioning

Benefit	Realized
<i>Reduced construction/warranty issues</i>	<i>11</i>
<i>Improved comfort control</i>	<i>13</i>
<i>Increased equipment reliability</i>	<i>8</i>
<i>Reduced O & M issues</i>	<i>12</i>
<i>Increased energy savings</i>	<i>10</i>
<i>Record of system operation and control sequences</i>	<i>14</i>
<i>Improved O& M manuals and training of O&M staff</i>	<i>12</i>
<i>Smoother turnover</i>	<i>12</i>
<i>Reduced IAQ issues</i>	<i>9</i>

Owners mentioned several other points: One owner valued commissioning because it provided a baseline for future recommissioning, and two owners mentioned the overall cost reductions realized through commissioning.

Scope of Commissioning Activities

<p>[Q 20] Please indicate which commissioning activities were included in your commissioning process. (Prompted)</p>	<p>n=18</p>
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Most commissioning activity currently focuses on testing of equipment and fails to cover the design phase. All respondents include functional testing as part of their commissioning process. In addition, over three-quarters of respondents include developing documenting sequence of operation and approving O&M manuals. Other activities are less prevalent. Notably, less than half the respondents included conducting a commissioning focused design review and less than one-third included developing a preventive maintenance program. Table C12 lists the commissioning activities and owner responses.

Table C12: Activities Included in Commissioning

Commissioning Activity	Yes	No	Don't Know
<i>Documenting design decisions/criteria during programming</i>	3	4	11
<i>Commissioning-focused design review</i>	8	6	4
<i>Developing full design intent documentation</i>	8	9	1
<i>Verifying code compliance during design</i>	9	7	2
<i>Developing system performance criteria</i>	13	3	2
<i>Developing a comprehensive commissioning plan</i>	12	5	1
<i>Developing functional test protocols</i>	12	2	4
<i>Conducting/ or overseeing equipment functional tests</i>	18	0	0
<i>Verifying operator training</i>	12	5	1
<i>Performing operator training</i>	11	7	0
<i>Documenting sequence of operation</i>	14	3	1
<i>Approving O&M manuals</i>	15	2	1
<i>Developing a preventive maintenance program</i>	5	11	2

Type of Firm Hired

[Q 21] What type firm is generally hired to do commissioning on your projects?	n= 18
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One third of owners hire Mechanical/Electrical engineering firms to perform commissioning activities. Almost one-third hire a commissioning consultant. Table C13 shows the types of firms hired. Several respondents designated more than one type of firm hired. Some owners hire different commissioning providers depending on the particular needs of the project; other owners are moving toward hiring an independent commissioning provider while continuing to do some in-house commissioning.

Table C13: Firms Hired to Perform Commissioning

Type of Firm	Response
<i>Architectural</i>	<i>3</i>
<i>TAB contractor</i>	<i>3</i>
<i>Mechanical/Electrical engineering firm</i>	<i>6</i>
<i>Consulting engineering firm</i>	<i>1</i>
<i>Commissioning consultant</i>	<i>5</i>
<i>Don't know</i>	<i>2</i>
<i>Other</i>	<i>5</i>

The “Other” category includes:

EMS firms

Contractors

Who Contracts for Commissioning?

[Q 22] For your projects that included commissioning, who contracts for (directly hires) the commissioning services? n=18

Three-quarters of respondents indicated that they directly contract for commissioning services. Table C14 lists the responses.

Table C14: Who Contracts for Commissioning Services

Who Contracts	Response
<i>Building owner, directly</i>	<i>14</i>
<i>Architect</i>	<i>1</i>
<i>General contractor</i>	<i>2</i>
<i>Mechanical/Electrical engineer</i>	<i>0</i>
<i>Construction manager</i>	<i>1</i>
<i>Utility</i>	<i>1</i>
<i>Don't know</i>	<i>0</i>
<i>Other</i>	<i>0</i>

Stage of Implementation

[Q 23] Which stages of the construction project include commissioning activities? n= 18

For the majority of owners, commissioning activities are confined to the construction and post-construction phases. Only two owners include commissioning in the pre-design phase and slightly less than half include commissioning in the design phase. Table C15 shows the pattern of commissioning activities. Respondents were asked to select all that apply.

Table C15: Phases that include commissioning

Phase	Response
<i>Programming (pre-design phase)</i>	2
<i>Design (bid) phase</i>	8
<i>Construction phase</i>	12
<i>Post construction / warranty phase</i>	10
<i>Don't Know</i>	2

Reasons for Stage of Implementation

The following question seeks to understand why owners begin commissioning their projects where they do. The surveyor asked each owner to justify his or her response to Question 23, filling in the blank with the first phase where commissioning activities occur.

[Q 24] Why do you begin commissioning at the _____ stage in the construction process?
(Unprompted) n=16

Most responses reflect the fact that commissioning is not standard industry practice. Some respondents think of commissioning as testing, adjusting, and balancing. Others know it is broader, but have difficulty beginning it earlier because of a lack of cooperation between all the parties involved in the process. In many cases, current protocol does not include broad commissioning activities, and/or government systems are not in place to fund commissioning. Most respondents expect that they will broaden the scope of their commissioning activities in the future.

Those who began at construction cited lack of money, cooperation, or knowledge. Some of their comments were:

- ☞☞ “The budget hasn’t included any other phase.”
- ☞☞ “That’s when the State pays for it.”
- ☞☞ “During design, we were focused on energy efficiency but we didn’t incorporate commissioning because it was hard enough just to do the design assistance for energy efficiency.”
- ☞☞ “It’s a battle to get mechanical engineers to let a commissioning agent in.”
- ☞☞ “I wasn’t aware of commissioning in the prior two phases.” (Pre-design and design.)

Those who began at programming or design had learned from experience. A few notable responses included:

- ☞☞ “Because of problems with an earlier construction project”

- ✍✍ “A review of the design is important, so that there are no problems during testing later.”
- ✍✍ “When you develop the design intent document, somebody needs to be there who knows the overall goals of the building.”

Future Commissioning Plans

[Q25, Q26] Do you plan to use commissioning as a quality assurance strategy in any of your future projects? If so, what type buildings are you planning to commission, and what is their square footage? n=18

Over 80% of respondents (15 of 18) say they plan to use commissioning in the future. The three who said no or maybe gave the following reasons:

- ✍✍ They don't know how much cost will be added onto the budget, and commissioning will probably negatively impact the construction schedule.
- ✍✍ The government requires them to go with the low bid, which doesn't include commissioning.
- ✍✍ The results of the current commissioning project will determine whether they use it in the future.

Thirteen owners estimated future commissioning projects. Their rough projections total almost six million square feet. (Note that two million square feet are planned by one owner.) Table C16 shows the plans for future commissioning projects and their square feet.

Table C16: Plans for Future Commissioning Projects

Survey	Future Commissioning Projects	Approx. Square Feet	
202	Marine Science Building	80,000	
202	Engineering 3 and 4	200,000	
202	Life Science Building	100,000	
206	County Jail	600,000	
207	Police Station	30,000	
208	Computer Facility	20,000	
209	Don't Know (dk)	Don't Know (dk)	
211	Buildings	2,000,000	
212	Office	500,000	
213	Fine Arts Facility	130,000	
213	Dormitory	100,000	
213	Lab	40,000	
215	Commercial Office Building	300,000	
215	Commercial Office Building	300,000	
216	High School	dk	
216	High School	dk	
219	dk	dk	
223	Crime lab	50,000	
223	Police training facility	50,000	
224	high-rise	650,000	
224	mid-rise	350,000	
224	University low-rise	450,000	
TOTAL	Twenty two projects	Square Feet::	5,950,000

Retrocommissioning: Strategies to Improve Existing Building Performance

The following questions characterize owners' practices as they relate to existing building performance.

Buildings Owned

[Q27] How many existing buildings do you own and operate in California?	n=24
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Half the respondents own 100 or more buildings, with the largest owner holding 450 buildings. Collectively, the owners surveyed hold over 3,000 buildings. Table C17 shows the number of buildings owned per respondent.

Table C17: Buildings Owned in California

Survey #	Buildings owned
201	1
202	300
203	150
204	100
205	25
206	400
207	150
208	200
209	200
210	100
211	80
212	60
213	23
214	Dk
215	243
216	450
217	150
218	30
219	50
220	12
221	9
222	12
223	300
224	15
Total Buildings	3060

Snapshot of current strategies

[Q 29] Do you use any of the following strategies to ensure building performance in your existing buildings?(Prompted) n=24

More than 85% of respondents cited the following four practices:

- ~~///~~ Monitoring equipment using handheld tools
- ~~///~~ Scheduling preventive maintenance
- ~~///~~ Periodically training O&M staff
- ~~///~~ Trend logging through the energy management system and/or using portable data acquisition equipment

Less than 40% of owners use periodic rigorous O&M assessments and tune-ups to ensure building performance. Table C18 shows owners' responses.

Table C18: Strategies to ensure building performance

Strategy		Used
<i>Monitoring and troubleshooting using handheld tools (multimeters, ammeters, flowhoods etc)</i>		23
<i>Trend logging through the energy management control system</i>		21
<i>Comparative analysis of the trend log data that is gathered by the energy management control system</i>		17
<i>Short-term monitoring of systems and temperatures using portable data acquisition equipment</i>		18
<i>Long term monitoring of systems using permanently installed metering equipment</i>		14
<i>Energy accounting software for tracking and analyzing utility bills</i>		13
<i>Scheduled preventive maintenance</i>		22
<i>If yes, how was it scheduled?</i>	<i>Computerized Maintenance Management System (CMMS)</i>	16
	<i>Manual maintenance log</i>	8
	<i>Service contract</i>	8
<i>Periodic rigorous and systematic O&M assessments and tune ups</i>		9
<i>Periodic training for O&M staff</i>		22

Some of the owners elaborated on their strategies:

Analysis of trend log data: 20% of respondents use spreadsheets such as Excel to generate graphs and visually analyze the EMS data. Only two compare data between buildings or to benchmarks. One respondent reported great satisfaction with PACRAT, the Performance Analysis and Continuous Recommissioning Analysis Tool, to trouble-shoot building systems, although he had only just begun using it.

Long term monitoring of systems using permanently installed equipment: Although twelve owners cited long term monitoring of systems, six of them confirmed that the monitoring is merely a standard part of the EMCS. Owners who actually went beyond EMCS monitoring mentioned voltage meters and vibration analysis monitors.

Scheduled preventive maintenance: This is widely practiced. Two thirds of respondents have some form of computerized maintenance management system. Manual maintenance logs and service contracts are also used by one third of respondents. One respondent noted that they are moving away from prescriptive preventive maintenance toward performance based contracts.

Periodic Training: Respondents almost universally affirm that they perform periodic training of O&M staff, but the frequency and quality of training varies. Approximately half the owners perform training only for new hires or new equipment, and another two wait for problems to arise. The majority of owners schedule trainings once a year or less. Three-quarters of the trainings are performed in-house and the most common topics are safety and new equipment. The owners who elaborated on routine training topics mentioned set points, steam traps, boiler theory, and overall building systems.

Other Strategies to Ensure Existing Building Performance

[Q 30] What other mechanisms or strategies, such as software or assessment tools, do you use to ensure that your existing facilities perform optimally? n=24

While many respondents felt the list presented in Table C18 covered all strategies, several owners mentioned these other strategies:

- ~~///~~ Old-fashioned eyes and ears (2)
- ~~///~~ Tenant complaints (3)
- ~~///~~ PACRAT software (2)
- ~~///~~ Microturbines to ensure energy supply and weather stations to predict weather patterns and shift energy usage accordingly (1)

Tools for the future

[Q 31] What types of software or assessment tools that you don't already use would benefit you in troubleshooting and operating your buildings? n=24

Survey respondents expressed strong interest in automated diagnostics. The range of functions and level of automation varied, however. Respondents felt they would benefit from the following tools:

- ~~///~~ Diagnostic systems that detect and correct problems.
- ~~///~~ Commissioning software that monitors and verifies performance.
- ~~///~~ Real world software that shows how efficiency changes under various conditions
- ~~///~~ A chip on a light tube that indicates if a piece of equipment is on and if it should be on.
- ~~///~~ Diagnostics that keep air flow in line with actual building needs.
- ~~///~~ We've got vending machines that call for an operator when they need to be refilled.
How about a refrigerator machine that tells us when the bearing are hot.
- ~~///~~ Smart cards for the parking lot that know when you're in the building and can start a heat pump for your space when you park.
- ~~///~~ A portable, handheld system that scan the barcode on any piece of equipment and bring up the whole service history.

In other cases, respondents cited tools they were familiar with such as PG&E's CoolTools (2), the Whole Building Diagnostician (1), and PACRAT (2).

Respondents also thought the universal translator would be very helpful to allow integration of all building controls systems. In addition, they want better networking of building management systems, so that one could log on from a central location and monitor remote sites.

Several owners also requested software for energy tracking and energy accounting. Ideally they would like a tool that tracks utility consumption in real time and flags operators when usage is above a certain level. One respondent wanted an energy tracking program that gives an annual comparison of how much money was spent on utility bills versus what would have been spent if the space were designed and maintained properly.

The following comments are a sampling of owners' requests:

✍✍ "Computerized automatic diagnostics"

✍✍ "Lifecycle cost analysis that's fairly automatic. The problem with most cost estimating programs is they aren't done in existing buildings, and they aren't applicable to hospital data."

✍✍ "DDC programming software"

✍✍ "PG&E Cool Tools"

✍✍ "Real time utility consumption tracker"

Operator Training Needs

[Q32] In what areas do you feel your building operators could use more training?	n=24
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Almost half of respondents feel that building operators need more training in Building Automation Systems (BAS). Owners feel that operators do not know the system well enough to make any programming changes, or they know one system well but are limited by their knowledge of only one proprietary system. Owners would like flexibility in choosing a controls system, but they are hostage to whichever system the operators understand.

In addition to more training in BAS, owners would like to see more training in the following areas:

✍ Understanding design intent (3)

✍ Energy Efficiency (1)

✍ HVAC systems in particular (2)

Operation and Maintenance Concerns

Question 33 asked owners to evaluate a list of concerns for proper operation and maintenance of their facilities. Their responses are shown in Table C19. A majority of owners deemed every concern except "Ease of equipment repair and installation" as "most important." Notably, the need to reduce energy costs was cited as least important by 3 owners (one represented the City of San Francisco, and thus has access to low-cost city power).

Table C19: Importance of O&M Concerns

O&M Concerns	Least Important	Important	Most Important
<i>Indoor Air Quality</i>	0	5	19
<i>Fire, safety issues</i>	0	1	23
<i>Tenant Comfort</i>	0	7	17
<i>Preventive Maintenance</i>	1	11	12
<i>Reducing Energy Costs</i>	3	7	14
<i>Equipment Longevity/Reliability</i>	0	10	14
<i>Understanding how systems are intended to operate</i>	2	5	17
<i>Operator Training</i>	0	4	20
<i>Ease of equipment repair and installation</i>	3	11	10

The following other concerns were raised:

- ✍ Ongoing concerns with utility reliability
- ✍ Improved equipment operation manuals
- ✍ Diplomacy training for operators who must deal with tenants

Familiarity with Existing Building Commissioning

[Q34] Are you familiar with the term retrocommissioning or existing building commissioning? If so, what does retrocommissioning entail? n=24

Three-quarters of respondents were familiar with the term “retrocommissioning.” They offered the following definitions:

- ✍✍ “Testing to make sure the building is functioning as intended”
- ✍✍ “Systematically going back to assess how the system is operating to try to bring it back to its original intent.”
- ✍✍ “Going through all system components and looking at all operating sequences, to ensure that they operate according to design.”

One respondent objected to the term “retrocommissioning”: “If you don’t have a baseline, how can you go back and check against it?”

Retrocommissioning Experience

[Q35] (If familiar with the term retrocommissioning), Given the definition of retrocommissioning that I just read, have any of your existing buildings ever gone through a retrocommissioning process? n=18

Twelve owners, half the survey pool, have had an existing building commissioned.

Recent Retrocommissioning Projects

[Q36] If yes, describe your three most recent projects. n=12

Eleven owners described (in part) nineteen projects, totaling over three million square feet. Most respondents had completed fewer than three retrocommissioning projects. When we compare the total number of buildings owned (Question 27) to the number of retrocommissioning projects reported, we find that only nineteen buildings out of over 3,000 owned have been retrocommissioned. This is less than one percent of all buildings. Almost half of the retrocommissioning projects are office buildings. The projects are detailed in Table C20.

Table C20: Recent Retrocommissioning Projects

Survey #	Building Type	Year	Square Feet	Cost to retrocommission
201	Hospital	1999	276,000	\$25,000
202	student/staff lounge	1999	80,000	\$75,000
203	coroner's lab	1999	80,000	\$25,000
203	Courthouse	1994	130,000	\$65,000
205	Hospital	1997	10,000	\$200,000 (includes renovation)
209	Office	dk	Don't Know (dk)	dk
209	Office	dk	dk	dk
209	Office	dk	dk	dk
214	warehouse/office	1995	200,000	dk
214	Office	1998	500,000	dk
215	Office	1999	330,000	dk
215	Office	1999	330,000	dk
215	Office	2000	240,000	dk
216	High School	2000	200,000	\$35,000
219	Hospital	1987	400,000	dk
220	Youth Center	1993-95	dk	dk
220	City Hall	1993	189,000	dk
220	Community Park	1993	dk	dk
221	High Rise Office	1999	150,000	dk
Totals:			3,115,000	\$425,000

Overall, retrocommissioning is considerably less prevalent than new commissioning. (See Question 16: Eighteen owners reported 36 commissioning projects, totaling 8.5 million square feet.)

Budget for Retrocommissioning

[Q37] Which budget did the funding for the retrocommissioning come from?	n=11
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- ☒ Capital Expenditures (4)
- ☒ O&M (4)
- ☒ Utility (3)

Satisfaction With Retrocommissioning

[Q38] Were you happy with the results from the retrocommissioning project?	n=11
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Eight of the eleven respondents were happy with their results. Only one person was unhappy, because retrocommissioning was not thorough enough, and three others were unsure because the process was not yet complete.

Perceived Values and Benefits of Retrocommissioning

The following questions identify owners' perceptions about the benefits of retrocommissioning.

Benefits of Retrocommissioning

[Q39] What do you value most about having your buildings go through the retrocommissioning process? (Unprompted) [Q40] Did you realize any of these benefits? (Prompted)	n=8
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In response to an unprompted question, the eight owners who were happy with their retrocommissioning process each valued a different aspect of the work. The following benefits were **each** mentioned **once**:

- ☒ Improved comfort control
- ☒ Increased equipment reliability
- ☒ Reduced O&M issues
- ☒ Improved operating strategies
- ☒ Increased energy savings
- ☒ Elimination of complaints
- ☒ Increased productivity of occupants
- ☒ A check on the contractor

In response to a list of benefits, most owners agreed that they realized most of the benefits, including reduced O&M issues, and increased energy savings. Notably, only half the respondents cited improved training for O&M staff or improved O&M manuals. Table C21 shows their responses.

Table C21: Benefits of Retrocommissioning

Benefit of Retrocommissioning	Realized
<i>Improved comfort control</i>	7
<i>Increased equipment reliability</i>	7
<i>Reduced O&M issues</i>	7
<i>Improved operating strategies</i>	6
<i>Increased energy savings</i>	7
<i>Improved training for O&M staff</i>	4
<i>Improved understanding of system operation</i>	8
<i>Improved O&M manuals</i>	4
<i>Reduced IAQ issues</i>	5
<i>Other*</i>	1

* One respondent commented that retrocommissioning generated good will from the tenants, as they noticed activity in the building.

Future Retrocommissioning Plans

[Q41, Q42] Is your company planning to perform any rigorous O&M tune-ups or retrocommissioning type activities on any of your facilities within the next five years? If so, what type building and what is the square footage? n=12

Two-thirds of owners who have done retrocommissioning in the past are planning more within the next five years. The four respondents who are not planning to retrocommission any facilities have either recently completed retrocommissioning or they perceive that the cost of retrocommissioning would outweigh the benefits. Their comments included the following:

☞☞ “Too much money”

☞☞ “No plans to do it on our own, without utility funds. We retrocommissioned one building last year with utility funds, and didn’t find anything major.”

☞☞ “We only have one building, and it was retrocommissioned.”

Respondents described nine future retrocommissioning projects, totaling almost two million square feet in the next five years. Projects include four government projects and three privately owned commercial offices. Table C22 shows the type of building and the square feet planned for retrocommissioning.

Table C22: Retrocommissioning Plans in the Next Five Years

Survey Number	Building Type	Square Feet
202	<i>Government Laboratory- University</i>	<i>160,000</i>
202	<i>Government Laboratory- University</i>	<i>134,000</i>
203	<i>Airport terminal</i>	<i>300,00</i>
205	<i>Medical Office</i>	<i>100,000</i>
211	<i>Commercial Office</i>	<i>140,000</i>
215	<i>Commercial Office</i>	<i>330,000</i>
216	<i>Government - High School</i>	<i>200,000</i>
220	<i>Government - City Hall</i>	<i>189,000</i>
224	<i>Commercial Office</i>	<i>250,000</i>
<i>Total square feet</i>		<i>1,803,000</i>

Commissioning and Retrocommissioning Market Opinions

The next group of questions addresses the barriers to increasing the market demand for commissioning and retrocommissioning services as well as strategies for overcoming the barriers.

Barriers to Commissioning and Retrocommissioning

[Q43] Please rate the each of the following barriers to making commissioning or retrocommissioning part of standard industry practice. (Prompted)	n=24
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Lack of budget was cited as a very significant barrier to commissioning by three-quarters of the respondents.. This is striking, given that less than 10% of providers cited lack of funding as a barrier to commissioning (Provider Question42). This suggests that providers may feel that funding would not be an issue if the benefits were better understood. Also, providers tend to think in terms of life cycle costs while owners are more concerned with first costs. In addition, lack of general awareness about commissioning and perceived high costs were rated a significant or very significant barrier to commissioning by more than eighty-five percent of respondents. The owners were less concerned about perceived additional time required by O&M staff to participate in the retrocommissioning process, perhaps because they don't perceive that retrocommissioning entails any staff time. Only four respondents ranked "lack of available commissioning providers" as a significant barrier, but the low ranking does not indicate that providers are plentiful; merely that owners are using in-house commissioning agents and aren't seeking them outside their regular operations staff. Owners' opinions are split over the significance of " lack of support by senior decision-makers." This barrier was more significant to government owners who were subject to government oversight. Table C23 shows the owners' opinions on barriers to commissioning.

Table C23: Barriers to Commissioning

Barriers to commissioning or retro-commissioning construction projects	Least	Significant	Most	Don't Know
<i>Lack of general awareness about what commissioning or retrocommissioning is.</i>	3	7	14	0
<i>Perceived high cost for commissioning or retrocommissioning</i>	3	5	16	0
<i>Perceived additional time required to complete commissioning tasks, thus slowing the construction process.</i>	7	8	9	0
<i>Perceived additional time required by O&M staffs to participate in the retrocommissioning process</i>	16	3	5	0
<i>Lack of available commissioning providers to perform commissioning or retrocommissioning</i>	8	11	4	0
<i>Lack of documented costs and benefits</i>	4	11	9	0
<i>Lack of budget</i>	3	2	18	1
<i>Lack of certification process for commissioning providers</i>	10	8	5	1
<i>Lack of support by senior decision makers in your company</i>	9	5	9	1

Some owners commented on the lack of awareness of the need for commissioning:

- ☞☞ “The perception is that if it’s built according to specs, it will work.”
- ☞☞ “There’s the perception that you’re already getting these services with the design engineer and the contractor.”

Other comments **displayed** this lack of awareness:

- ☞☞ “It’s just another layer and creates a tremendous amount of paperwork.”
- ☞☞ “We wouldn’t need it [commissioning] if we had an honest contractor.”

And some people cited a lack of coherent, standard practices as a barrier:

- ☞☞ “NEBB certifies commissioning agents, but starts commissioning toward the end of construction. This confuses people.”
- ☞☞ “Individual department managers only see one part of the pie, so commissioning isn’t as important to them.”
- ☞☞ “Adding one more person to the design team adds one more voice to the chaos.”
- ☞☞ “Training is lacking.”
- ☞☞ “We need to integrate commissioning into design/build construction projects.”

Methods for Increasing Market Demand

[Q 44] Please rate the following strategies for increasing the demand for commissioning and retrocommissioning services. (Prompted)	n=24
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Over 60% of respondents deemed the following four strategies “Most Effective”:

- ✍ Low or no-cost informational workshops
- ✍ Demonstration Projects
- ✍ Funding of Commissioning by Utility EE Programs
- ✍ Code Requirements

Notably, code requirements were seen as effective but not necessarily a good idea: a “hammer” that might create resentment. Tax credits were designated “least effective” by 30% of respondents, as government employees do not pay taxes on their projects. However, among the private owner respondents, nine of ten designated tax credits as effective or most effective. Clearly, the public and private sectors will require different incentives. The tally of owners’ opinions is shown in Table C24.

Table C24: Methods for Increasing Demand for Commissioning and Retrocommissioning

Method	Least	Effective	Most	Don’t Know
<i>Tax credits</i>	6	9	8	1
<i>Example commissioning specifications for construction documents</i>	6	11	7	0
<i>Certification for commissioning providers</i>	6	13	5	0
<i>Low or no cost informational workshops on building commissioning and retrocommissioning</i>	3	5	15	1
<i>Demonstration projects and case studies that demonstrate benefits of commissioning in new and existing buildings</i>	1	5	18	0
<i>Funding of Commissioning Activities by Utility EE Programs</i>	0	3	20	1
<i>Code requirements for commissioning of new buildings</i>	2	6	16	0
<i>Increased availability of commissioning related information (on the web and in professional journals) targeted at building owners/managers</i>	3	9	12	0

While private owners feel that the list of strategies in Table C24 is comprehensive, government employees suggested strategies unique to the public sector that would induce them to include commissioning in their new construction projects. The following suggestions for increasing market demand are from government owners:

- ✍✍ “A rebate program to go directly to the operational guy, not the general fund.”
- ✍✍ “A legal mandate for public agencies to include commissioning.”
- ✍✍ “The politicians need to know the value of commissioning.”

Owners offered several strategies that would influence them to retrocommission their existing buildings. The “carrot” of utility incentives is again more popular than the “stick” of code enforcement, but several owners admitted that if their buildings were checked more rigorously for code compliance and health concerns, the consequent red flags would trigger a retrocommissioning. In other words, owners retrocommission buildings when they see a problem; retrocommissioning will increase as owners obtain a clearer picture of actual building performance, through improved diagnostic tools and closer oversight. Owners suggest the following strategies to increase demand specifically for retrocommissioning:

- ~~///~~ Utility incentives
- ~~///~~ Comparative benchmarking and performance calculations to raise red flags and point to the need to retrocommission
- ~~///~~ Retrocommissioning workshops in actual buildings that need retrocommissioning

Commissioning Costs, Savings and Infrastructure Estimates

We conducted an analysis to estimate what the commissioning costs and associated energy savings might be for the State of California if commissioning is adopted in both existing buildings and new construction. The requirements for a commissioning infrastructure to support such an effort are also considered.

Approach

The following lists the major steps for accomplishing this task:

1. By building sector, determine the quantity of existing building stock and estimate the quantity of new construction floor area that could be commissioned.
2. Estimate the costs for commissioning and how many commissioning providers would be needed to perform the commissioning of the floor area identified in step one.
3. Estimate the energy savings from commissioning new and existing buildings and the payback from energy alone for commissioning.

The following describes these tasks in more detail.

Floor Area Forecast for Commissioning New and Existing Buildings

This task was accomplished by obtaining building stock projections for the current and future years by building sector. A table of projections was obtained that had data by utility and summed for the entire state. The data was received on 10/10/00 from Tav Cummins of CEC in the Excel file: flspc_by_zone_1.xls. We used the state-wide numbers for our analysis. The data in the CEC forecast contains existing building stock in square footage of floor area for 11 building sectors. It also includes forecasts of added floor area for new construction for each year and building sector (see Table B-3 in Appendix B). In our analysis, we include eight of the 11 sectors: office, restaurant, retail, grocery, school, college, hospital and lodging. However, the restaurant sector had no stock greater than 25,000 sf, but was retained as a place holder in the spreadsheets for future analysis of smaller sites. We did not include the two warehouse sectors and the miscellaneous sector. For the new construction square footage we use the value given in the CEC forecast for 2003, as it seems representative of the forecast for the next 10 years. Table B-3 presents this data.

The CEC data is not broken down into building sizes other than small and large office. Since no information could be obtained on what floor area characterized “small” and “large” we combined these two sectors. However, it is important to consider size for a commissioning analysis, since commissioning as currently practiced is only incorporated into buildings over 25,000 sf or so. Since we were unable to locate this data for California as a whole, we applied the proportional breakdown of floor area by building size for PG&E territory to the entire state. The source for the breakdown is PG&E’s *Commercial Building Survey Report—1999* downloaded from the PG&E website. This document presents data for eight floor area ranges. Using Tables 1 and 3 in that document we developed the fraction of total floor area that makes up each size group in PG&E territory. The results are found in Table B-4 in Appendix B in this report. We had to make a number of assumptions and simplifications because the original data is not detailed enough. For example, we knew the number of buildings within a given size group (e.g., 25,000 – 50,000 sf) but did not know the distribution within the size group. We therefore made the assumption that the average size in the group was mid-range in the group (e.g., 37,500). We need the average size in order to come up with the total floor area in each size group to determine the fraction this size group represents of the

entire sector. Additional details of the adaptations made to the data are found in the notes of Tables B-4, 5, and 6 in Appendix B.

We are not completely confident in the numbers developed for the total number of buildings and the total floor area in each size group. However, we feel that the numbers sufficiently represent the market for us to make observations regarding the magnitude of the potential for commissioning in California. Caution is urged when making hard comparisons between building sectors. Also, the estimates of current stock in PG&E territory varied between the PG&E study and the data we received from CEC, particularly in the schools, hospital and miscellaneous categories as shown in Columns B and C of Table B-4. If this type of commissioning analysis continues and more resolution and accuracy is desired, it will be necessary to obtain the total floor area for each size group for each sector and input it into Column H in Table B-5 and B-6 and reformulate the value for the % of Total SF, Column I.

We extended the estimate for the total floor area for each size group in PG&E's territory to the entire state of California assuming that the distribution of building sizes in PG&E territory was the same as the entire state. We did not analyze the validity of this assumption. We then applied the percent of total floor area for each of the size groups to the total floor area in the state for each of the market sectors for existing buildings (see Table B-5) and for new construction in (see Table B-6). The new construction numbers include new sites and additions, but do not include renovations.

As mentioned previously, it was necessary to exclude small buildings in the balance of the analysis. We selected the break point of 25,000 sf as being appropriate. This is a reasonable assumption since holistic commissioning is rarely practiced in facilities smaller than this, as it is generally hard to make the projects cost effective. Some projects and sectors, like hospital additions, would be exceptions, but the break was the same for all building types to keep this high level analysis simple.

Penetration Rate Estimates

For market projection purposes, we chose penetration rates for commissioning and retrocommissioning of buildings greater than 25,000 sf. For existing buildings, a penetration rate of 2.0% per year is applied to all sectors (see Table B-1). This means we are assuming that for every year, 2% of the total existing building stock will go through a retrocommissioning process. For new construction, a penetration rate of 30% per year is applied to all sectors (see Table B-2). This means we are assuming that every year 30% of all new construction over 25,000 sf will go through the commissioning process. It has been our experience working with large building owners and utilities that it is difficult to penetrate the existing building commissioning market without significant marketing *and* financial incentives by utilities. New construction commissioning has been more readily adopted by owners. These rates are considered reasonable points of reference for a program or market that is transforming—not beginning and not fully developed. However, cases can be made to raise or lower them. It should be noted that the penetration rates assumed here are for retrocommissioning that involves a fairly comprehensive scope, rather than a limited energy study or a minor system tune-up. For new construction the penetration rate is for comprehensive commissioning from early design through warranty. The 30% penetration rate for commissioning new construction (in a transforming market) appears reasonable in light of the responses from the survey participants. The vendors indicate that for more than 30% of the new construction square footage some type of commissioning (mostly during construction) is already occurring.

Commissioning Cost Estimates

Existing Buildings

The commissioning costs for existing building commissioning vary dramatically with the objectives of the effort and the specific scope of services. In developing the cost projections, we selected a hypothetical scope that focuses the effort primarily on the reduction of energy and the enhancement and corrections to system control. Additionally, this scope targets major energy using systems and limits the effort at the zone level where there are numerous small pieces of equipment and much smaller incremental energy savings. The scope includes review of building documents, equipment inspection, building staff interviews, examination of controls (settings, schedules and system sequences), manual (site) testing, trend logging or datalogging and analysis, developing a findings report (including costs and savings estimates of the recommendations), providing limited assistance in implementing the fixes and selected retesting after implementing the fixes. No travel is included. The total costs also included the time for building staff to participate in the process. Costs for fixes, both hard or material costs, and subcontractor labor are also estimated. The focus on retrocommissioning is low-cost operational and maintenance improvements rather than equipment replacement. Retrocommissioning includes control programming, scheduling changes, control settings and setpoint improvements, and some small material costs like the addition of critical sensors, time clocks, or damper parts. It doesn't include such things as variable speed drives and motor replacements. The costs per square foot shown are for the average size building as shown in Table B-8a. Costs may be considerably higher per square foot for buildings smaller than the average and considerably lower for buildings greater than the average. The cost build up for existing buildings is found in Table B-8a and varies slightly by building sector.

New Construction

In developing the cost projections for new construction commissioning, a cost per square foot method is used, based on PECI internal costing models. Construction phase costs for these models have been calibrated with models and reports from other sources (see Table B-8b). We feel that the values are representative of the market place for the scope of work included. We increased the costs in this analysis from the direct PECI model results by about 20% to account for the generally higher consultant costs in California compared to Oregon. We compared our square foot costing model results with percent of total construction cost method to check our numbers and found adequate correlation (see Table B-8d).

The costs include comprehensive, but not total building commissioning from early design through warranty for all parties: owner, commissioning provider, designers and contractors. Design phase commissioning consists of: developing the owner's project requirements or objectives, commissioning-focused design reviews for systems at schematic, design development and construction documents phases, developing a commissioning plan and commissioning specifications. The notes in Table B-8b further describe the tasks of each of party.

Cost for commissioning of the equipment and systems includes the HVAC and controls, lighting controls, and emergency power. The cost for construction phase commissioning tasks include: reviewing submittals, observing construction, developing construction checklists, writing functional test, executing tests, verifying training and O&M manuals, and providing near-warranty end review. The costs per square foot presented are for the average size building as shown in Table B-8b. Costs

may be considerably higher per square foot for buildings smaller than the average and considerably lower for buildings greater than the average.

Commissioning Provider Cost Estimates

In estimating commissioning provider costs we use the commissioning provider costs only (not the other party costs) for all the commissioning in an entire sector for an entire year for the assumed penetration rate. This number is divided by an assumed annual loaded salary of a commissioning provider (\$80,000). The result gives the number of full time providers needed per year. No analysis was conducted on the additional infrastructure requirements for designers or contractors, since (combined) they only represent about a fourth the staff requirements as the commissioning provider.

Energy Costs and Savings Estimates

Energy Costs

The energy savings estimates are based on the total energy consumption of the building. This requires that for each building type we know the total energy use index (EUI). Since, we were not able to locate EUI information for the state as a whole, we extracted the information from the previously referenced 1999 PG&E report. Tables 21 and 22 in that report present both electrical and gas EUIs (we converted the electrical consumption in kWh to Btu and showed the entire facility energy use in kBtu). For this analysis, we use the EUI for each building sector in PG&E's territory for the entire state of California. Also, the EUIs given in the PG&E data are averages for all building sizes, but we limit our analysis to only the buildings greater than 25,000 sf. EUIs range from a low of 68 kBtu/sf/yr to 209 kBtu/sf/yr for grocery and hospital. The restaurant sector is even higher at 332 kBtu/sf/yr but this number is not used in the final analysis because there is no restaurant stock greater than 25,000 sf.

We obtained an electrical and energy rate forecast from CEC and use the average for all California utilities between now and 2010, converting to \$/kBtu. The data came from Lynn Marshall, Energy Specialist of the CEC in the files gaspricecomp.xls, elecpricecomp.xls and comp ced2000.xls on 10/25/00. CEC reported to us that the consumption cost numbers in the values they provided include typical demand charges. The EUI and energy costing development is presented in Tables B-7a and B-7b.

Savings Estimates

The energy savings are estimated as a fraction of the total energy consumption. They are based on PECI experience and correlate to the reports of others in the industry. However, the grocery, school and lodging sectors are not backed up with significant PECI experience.

Savings from existing buildings can vary from building to building. These represent averages. The average life of the savings for retrocommissioning is expected to be about 3-6 years based on PECI experience. The savings fractions for existing buildings are found in Table B-1 in the Appendix and Table 1 below.

The savings from new construction commissioning are based on implementing the recommendations and findings that would not have been made without commissioning. The savings include no-cost recommendations (other than some limited design time) during design meant to

improve or remedy oversights and deficiencies. They also include improvements and correction of deficiencies during construction. We assume that there are no costs for obtaining the energy savings attributed to commissioning other than the commissioning effort itself. Life expectancy of the energy savings from commissioning new buildings is assumed to be longer than energy savings from commissioning existing buildings, since the commissioning savings in existing buildings often come from operational changes that can be overridden or changed back to their original inefficient state. We estimate the life of new construction commissioning savings to average between 5 and 10 years. Savings life is not used in this analysis, but is mentioned for reference for those who may be putting levelized cost values to the commissioning savings. The savings fractions for new buildings are found in Table B-2 in the Appendix and Table 2 below.

Market Potential Results

Existing Buildings Market Potential

Table 1 provides a summary of the results and is an abbreviated version of Table B-1 in the Appendix. The sum of the floor areas greater than 25,000 sf for all sectors is 2.47 billion sf. By applying the penetration rate of 0.02 to this number, we can project retrocommissioning 49.4 million sf of existing buildings per year at an annual cost of \$12.8 million (Table B-1). The unit cost includes all parties and fixes and ranges from \$0.32 to \$0.47/sf for the average size building depending on market sector as shown in Table 1. Costs may be considerably higher per square foot for buildings smaller than the average and considerably lower for buildings greater than the average.

Energy savings range from 12% to 15% of total energy consumption and indirectly include demand reductions because the energy cost values that the savings fraction is applied to include typical demand charges. Energy savings for penetrating 2% of the buildings greater than 25,000 sf, totals 690 million kBtu annually and \$9.5 million. The simple payback from energy alone averages 1.8 years, well under its expected average “measure” life of 3 to 6 years. This makes stand-alone retrocommissioning an attractive energy conservation measure. Table B-1, Column M, shows the cost per kWh saved (from the entire kBtu converted to kWh) to be \$0.085. This is the initial one time cost for the first year savings (the savings repeat for the life of the “measure”).

The estimated number of full time commissioning providers required to commission the 49.4 million sf annually is 165 fully experienced individuals. This equates to 300,000 sf per year per full time provider. It is likely that less experienced individuals pulling an “experienced” salary will be doing much of the work in California and, at first, more providers will be required than the numbers in this report indicate.

Table 1. Commissioning Market Potential – Existing Buildings > 25,000 sf

	A	B	D	F	G	H	I	K	L
Sector	Energy Savings Fraction	Total Cost of Cx and Fixes (\$/sf)	Total Floor Area (millions of sf)	Annual Penetration Rate	Area Commissioned (1000's sf/yr)	Annual Energy Savings (Millions of kBtu)	Annual Energy Dollar Savings (Millions)	Payback From Energy Alone (yrs)	Needed Commissioning Consultant FTE
Office	0.15	\$ 0.34	722.00	0.020	14440.0	146.5	\$ 2.45	2.0	47
Restaurant	0.10	\$ 0.32	0.00	0.020	0.0	0.0	\$ -	n/a	0
Retail	0.15	\$ 0.32	395.35	0.020	7907.0	108.8	\$ 1.56	1.6	26
Grocery	0.12	\$ 0.33	101.94	0.020	2038.8	51.2	\$ 0.96	0.7	7
School	0.15	\$ 0.34	558.34	0.020	11166.8	98.0	\$ 1.20	3.2	36
College	0.15	\$ 0.33	226.46	0.020	4529.2	68.2	\$ 0.78	1.9	15
Hospital	0.15	\$ 0.47	268.70	0.020	5374.0	168.7	\$ 1.91	1.3	22
Lodging	0.15	\$ 0.34	195.45	0.020	3908.9	48.1	\$ 0.64	2.1	13
All Buildings			2468.24		49364.8	689.6	\$ 9.51	1.8	165

Column heading letters correspond to headings of the source Table B-1.

New Construction Market Potential

Table 2 provides a summary of the results and is an abbreviated version of Table B-2 in the Appendix. The sum of new floor area greater than 25,000 sf for all sectors is 61.4 million sf. By applying a penetration rate of 0.30 to this number, we can project commissioning 18.4 million sf of new construction per year at an annual cost of \$20.7 million (Table B-2). The unit cost includes the design and construction phases for all parties and ranges from \$0.87 to \$1.35/sf for the average size building depending on market sector as shown in Table 2. Costs may be considerably higher per square foot for buildings smaller than the average and considerably lower for buildings greater than the average.

Energy savings range from 6% to 9% of total energy consumption and indirectly include demand reductions because the energy cost values that the savings fraction is applied to include typical demand charges. Energy savings for penetrating 30% of the buildings greater than 25,000 sf, totals 147 million kBtu annually and \$2.08 million. The simple payback from energy alone averages 9.9 years, at the top of its average expected “measure” life of 5-10 years. Table B-2, Column M, shows the cost per kWh saved (from the entire kBtu converted to kWh) to be \$0.479. This is the initial one time cost for the first year savings (the savings repeat for the life of the “measure”).

The estimated number of full time commissioning providers needed to commission the 18.4 million sf annually is 182 fully experienced individuals. This equates to 101,000 sf per year per full time provider.

It is likely that less experienced individuals pulling an “experienced” salary will be doing much of the work in California and, at first, more providers will be required than the numbers in this report indicate.

Table 2. Commissioning Market Potential—New Construction > 25,000 sf

	A	B	D	F	G	H	I	K	L
Sector	Energy Savings Fraction	Total Cost of Cx In Design and Const (\$/sf)	Total New Const. Floor Area (millions of sf)	Annual Penetration Rate	Area Commissioned (1000's sf/yr)	Annual Energy Savings (Millions of kBtu)	Annual Energy Dollar Savings (Millions)	Payback From Energy Alone (yrs)	Needed Commissioning Consultant FTE
Office	0.09	\$ 1.07	21.56	0.300	6468.3	39.4	\$ 0.66	10.5	61
Restaurant	0.06	\$ 1.72	0.00	0.300	0.0	0.0	\$ -	n/a	0
Retail	0.09	\$ 1.07	10.28	0.300	3085.1	25.5	\$ 0.37	9.0	29
Grocery	0.07	\$ 1.59	2.78	0.300	833.5	12.2	\$ 0.23	5.8	12
School	0.09	\$ 1.20	11.51	0.300	3454.4	18.2	\$ 0.22	18.5	37
College	0.09	\$ 0.87	3.77	0.300	1131.5	10.2	\$ 0.12	8.4	8
Hospital	0.09	\$ 1.35	5.98	0.300	1795.3	33.8	\$ 0.38	6.4	21
Lodging	0.06	\$ 1.00	5.45	0.300	1635.8	8.1	\$ 0.11	15.3	14
All Buildings			61.35		18403.8	147.4	\$ 2.08	9.9	182

Column heading letters correspond to headings of the source Table B-2.

Issues and Recommendations

This section of the report discusses the most significant issues that emerged, based on the survey results, along with recommendations for how Pacific Gas & Electric Company can support and catalyze the growth of the commissioning market in California.

1. Issue: Owners' need education on commissioning for new and existing buildings (retrocommissioning)

Concerning new construction projects, our sample contained a number of owners that we knew had experienced commissioning, so it is no surprise that all of the respondents were familiar with the term "building commissioning." However when asked to describe commissioning, approximately three quarters the respondents defined commissioning as primarily the testing of systems. Only two mentioned the ASHRAE definition and only four described a larger process, beginning in design and continuing at least to turnover. The following comments are representative.

☞☞ "Performance and diagnostic testing."

☞☞ "Vendors performance-check systems more thoroughly than normal."

☞☞ "A check of a system's operations to ensure that they are meeting design intent."

☞☞ "Making sure motors turn in the right direction, pressures are correct, etc."

☞☞ "The inspection, testing, and training process to ensure that a building is built and operated as intended by the design engineer."

☞☞ "Test everything as you bring it on line."

☞☞ "Going in with a technical team to make sure the EMS is running as it should."

Further, when owners were asked to indicate which commissioning activities were included as part of their projects, 100% said "yes" to conducting and overseeing functional testing of equipment. 83% did not know or said "no" to documenting design criteria during programming and over 50% either didn't know or said "no" to both commissioning-focused design review and developing full design intent documentation.

From the commissioning provider perspective, when asked if they were satisfied with the current state of the market, four-fifths of the commissioning providers said no and offered the following comments on the need for owner education:

☞☞ "There has to be a paradigm shift in owners to understand that they don't get everything for nothing."

☞☞ "Owners don't see the value or are uneducated."

☞☞ "Many owners look at the cost associated with full commissioning and turn it down."

☞☞ "There needs to be more awareness of what building commissioning can do for a building and how the benefits are far greater than the costs to have it done."

Concerning retrocommissioning, most owners claimed they were familiar with the term “retrocommissioning” however, five owners had not heard of the term. When asked to describe retrocommissioning, owners offered the following mix of responses:

- ☞☞ “Testing to make sure the building is functioning as intended.”
- ☞☞ “A retrofitting process.”
- ☞☞ “Systematically going back to assess how the system is operating to try to bring it back to its original intent.”
- ☞☞ “Continuous commissioning and tune-ups.”
- ☞☞ “Going through all system components and looking at all operating sequences, to ensure that they operate according to design.”
- ☞☞ “Commissioning of a retrofit is more involved because you have an existing building.”
- ☞☞ Applying the commissioning process to existing buildings.”

Only three of the owners mentioned optimizing the building to operate according to original intended design. None of them mentioned the possible need to rebuild the original design intent information and determine how it had changed appropriately or inappropriately over time.

It is apparent from their responses that most owners lack a real understanding of what retrocommissioning entails. Although they were not asked a direct question about who performed the service, none of the owners mentioned hiring an outside expert. After hearing a definition of retrocommissioning, twelve of the owners claimed that they had retrocommissioned at least one building. However, the confusion about the process again becomes apparent when we juxtapose this against an earlier question that asked about building performance strategies. Only nine owners said they used periodic and “systematic” O&M assessment and tune-ups as a way to ensure building performance. Some elaborated on what that means:

- ☞☞ “Every six months we go through all the equipment.”
- ☞☞ “Annual in-house assessments. Also, capital expenditure budget analysis on every building and life cycle analysis on every piece of equipment.”
- ☞☞ “Annual preventive maintenance and evaluation of systems.”
- ☞☞ “In-house staff do this.”

Recommendations:

Owners indicated that the most significant barriers to making commissioning a part of standard industry practice are (in order of importance) lack of budget, lack of general awareness about the concepts of commissioning and retrocommissioning, and the perceived high cost of each process. Regarding education as a solution, owners selected “low-cost or no-cost workshops” as an effective method for increasing market demand for both retrocommissioning and commissioning services along with demonstration projects and case studies that demonstrate the benefits of the processes. Ninety percent of the commissioning providers, when asked to rate strategies for increasing market demand for commissioning services, rated “educational programs for building owners and their staff” as most or very effective. Their second highest choice was to provide case studies that demonstrate the benefits of commissioning.

Based on the survey findings and our experience with the commissioning market, we recommend that PG&E continue to develop educational workshops that address the importance of

commissioning during design, the value an outside expert may bring to the process and what the full commissioning process entails. It is important for owners to understand that including commissioning early in the design/construction process reduces costs for testing and reduces the need to “fix” problems (especially as they relate to design) later in the process.

We also recommend developing case studies demonstrating the costs and benefits of integrating commissioning throughout all of the construction phases. The case study information could be gained by funding secondary research. A potentially valuable source of information is the Northwest Energy Efficiency Alliance’s Commissioning of Public Buildings Program. The program is currently underway and intends to develop case studies within the next two years on new building commissioning. Many of the findings will be generic to typical commercial buildings. Interestingly, none of the buildings thus far (due to the timing of the program) include commissioning during the design phase. However, research and analysis of project issue logs (deficiency list and solutions) could reveal solid information on how including commissioning during design may have resulted in an improved cost/ benefit ratio. This level of analysis is not part of the case study process for this program but the information will be available for anyone interested in performing further research.

Regarding retrocommissioning, the findings also indicate a need to educate owners about what retrocommissioning means, what the process entails, and the benefits. PECI recommends that PG&E develop introductory educational workshops for owners on retrocommissioning. These should be structured with an emphasis on the process and benefits. Case studies are more readily available that show the costs and benefits of retrocommissioning than commissioning but some funding may be needed to update the cost side of the equation. Given the number of existing buildings and the fact that most buildings do not go through a formal commissioning process, the opportunity for energy savings is greatest in existing buildings.

2. Issue: Contractors need education about commissioning for new construction projects

The survey findings reveal that providers are experiencing a lack of cooperation by the construction contractors during the commissioning process. Implementation is difficult because the contractors do not understand the process, their role, and the how it benefits them. The following lists some example comments from providers when asked a general question about commissioning implementation problems:

- ☞☞“Contractors resist the process which impacts commissioning and the total project schedule.”
- ☞☞“Subcontracting parties on a project, for example the controls contractor, say they’re done when they are not.”
- ☞☞“Difficulty with control contractors being non-responsive and poor control documentation.”
- ☞☞“Lack of understanding of the commissioning process. Unsatisfied contractors that give commissioning a “bad rap” because there is a lack of understanding of the technical effort needed for commissioning.”
- ☞☞“Contractors not filling out verification check lists and controls contractors not ready with control sequences.”
- ☞☞“General contractor is behind schedule and doesn’t understand the building delivery process when commissioning is part of the project.”

Recommendation:

PECI recommends that PG&E develop educational workshop that target the construction contractors (general and subcontractors) with an emphasis on controls, mechanical and electrical contractors. Cooperation by all parties is necessary for successful and cost-effective commissioning. Because contractors are not familiar with commissioning and do not see how it benefits them, they are resistant and often adversarial. The following lists some examples of topics that the workshops should address:

- ✍️ Introductory information on the commissioning process
- ✍️ How commissioning benefits contractors
- ✍️ The role of each contractor in the process
- ✍️ How to perform checklist and other commissioning requirements efficiently
- ✍️ What information is typically required from them by the commissioning provider

3. Issue: Owners and providers need promotional materials for commissioning and retrocommissioning

Commissioning resources and informational materials would be valuable to both owners and providers. Owners need information on the value of commissioning and information that will provide guidance through their first commissioning project. Providers need technical information that will save them time and help them become more cost effective.

Most providers feel that owners have the ability to fund commissioning activities if they want to. Providers point to overall lack of understanding commissioning and its perceived high costs / lack of benefits as the main barriers to commissioning. Owners' responses also indicate that marketing materials would increase their awareness of commissioning services. Case studies were rated as a very effective method of increasing commissioning awareness by three-quarters of all owners. Building owners new to commissioning will also need materials to help them understand the commissioning process and their role within it.

Commissioning providers typically use their own commissioning process. This means that each provider develops his or her own commissioning plan, pre-functional checklists, functional test requirements, database for recording data and final report. Considerable time could be saved if commissioning providers had access to standardized commissioning documents and testing protocols -- even though they would need to be modified for each commissioning project. Providers in our survey were generally interested in standardized commissioning procedures and specifications but expressed caution about who would develop these standards. Commissioning providers were also interested in keeping abreast of state-of-the-art commissioning practices.

Recommendations:

PECI recommends that PG&E consider developing commissioning resources and information materials for use by both owners and providers. Specifically, PG&E should consider developing the following materials:

- ✍️ Commissioning marketing materials, such as documented case studies, directed at owners.
- ✍️ Commissioning resources targeting designers
- ✍️ Standardized commissioning procedures and testing protocols that would build on PECT's Model Plan and Guide Spec, but be reformatted for easier use by new commissioning providers.
- ✍️ Materials on advanced and state-of-the-art commissioning practices -- possibly in the Design Brief format.

4. Issue: Owners rarely request commissioning services

When prompted with a list of barriers to their firm incorporating commissioning for new buildings as a standard business offering, over 80% of the commissioning providers consider “clients not requesting the service” as the most significant barrier. This echoes their perception that owners lack an understanding of commissioning and that the owners think they are “already getting it” as part of the construction process. Other comments include:

- ✍ “Many customers are scared away by the first costs of commissioning since the savings are difficult to guarantee.”
- ✍ “Lack of time, today’s tight construction schedules, and owners still not convinced of its benefits.”
- ✍ “The first cost driven mentality of many owners.”

When providers were asked similar questions regarding retrocommissioning, ninety percent responded that the benefits and costs were not well understood and 55% noted a lack of understanding of what retrocommissioning is.

When asked to rate strategies for increasing demand, 65% of the providers felt that utility financing programs are very or most effective. When owners were asked a similar question, 20 out of the 24 owners rated the strategy as most effective. This is not surprising since three quarters of the owners cited “lack of budget” as the main barrier to requesting commissioning or retrocommissioning services.

Recommendation:

PECI recommends that PG&E develop incentive programs to jump-start the California commissioning/retrocommissioning industry. Concerning new construction projects, PG&E should continue with plans to offer owners a financial incentive for developing a commissioning plan. With a commissioning plan “in hand” and paid for, it is more likely that an owner will see the benefits and want to follow through with the plan.

One suggestion for implementing a program such as this is for the utility to reimburse the owner for having a commissioning expert develop a plan. Ideally, the commissioning plan needs to happen as early as possible in the planning stages of a new project. The caution here is to design the program to ensure that the commissioning plan encompasses both commissioning during design and during construction. Our experience indicates that including commissioning during design increases the cost effectiveness of an entire commission effort. Another caution is to design the program to avoid allowing inexperienced or unqualified vendors from participating just to get in on the incentive money. This could ultimately give commissioning a “bad name”.

Concerning existing buildings, PEGI recommends a similar approach. PG&E should consider offering owners a financial incentive for having a retrocommissioning (enhanced O&M) assessment performed on their facility. The retrocommissioning process, although it looks at immediately optimizing how buildings operate through improving O&M strategies, it also offers a way for the owner and utility to identify potential retrofit opportunities. There is already a model for this type of program in the Pacific Northwest., Portland General Electric’s Retrofit Commissioning Program. Lessons learned from this model should be studied and incorporated into the PG&E program.

For incentive programs such as these to realize their intended benefits, the marketing must be well designed. Because increasing demand is a goal, marketing for the program must speak to both the customer and vendor with an emphasis on the customer. Building owner and developer awareness of the program will ultimately drive the requests since service providers are often too busy to market the program for the utility.

5. Issue: The industry needs to build a credible infrastructure

When providers were asked to rate strategies for increasing the quality of commissioning, almost two-thirds of them rated “standardization of commissioning requirements” as very or most effective for increasing the quality of commissioning. Standardization of commissioning requirements was also mentioned as a way to increase the cost effectiveness of commissioning.

Another question that prompted providers to comment on the quality of commissioning services was on whether they are satisfied with the current state of the market. One-third are unhappy with the lack of consistency among providers, as it may give commissioning a bad name. Providers made the following comments:

- ☞☞ “[There are] contractors who say they are providers of commissioning services but they really are not performing true commissioning.”
- ☞☞ “People are driving down the cost with compromises in quality. Shyster commissioning providers in the market don’t provide real commissioning.”
- ☞☞ “Poor implementation has led to owners questioning whether the expense is worth it.”

Recommendations:

Whenever a new service or profession emerges, it is wise to have concerns about practitioner qualifications and the quality and consistency of the service. Without quality assurance mechanisms in place, commissioning could suffer setbacks that could take years to overcome. PG&E can help catalyze this market by assisting in the formation of quality assurance mechanisms that are already evolving. The following discusses three recommendations for building a credible commissioning infrastructure:

ASHRAE is currently working to make their existing commissioning guideline more comprehensive. They are developing a generic guideline that will cover all building systems along with a more comprehensive guideline for HVAC systems. This work offers to meet the need for more standardization of commissioning requirements. However, it is a slow process since developing the guidelines is a voluntary effort by ASHRAE members.

PECI recommends that PG&E support ASHRAE in their effort to draft a more comprehensive commissioning guideline by providing funding to the committee (GPC 1-1996R) responsible for accomplishing the task. At minimum, the funding for one individual to write the draft guideline would expedite the process considerably.

The Building Commissioning Association (BCA) is a national professional organization whose members and leadership are well aware of the need for quality and consistent commissioning services. It is part of the BCA’s mission to effectively address the concern that commissioning services often vary in scope, quality, and objectives. The organization does this in three major ways. First, they developed and adopted a foundation document titled *Building Commissioning Attributes*

(*Attributes*). This document identifies what the BCA believes is the essence of effective commissioning and all members must agree in writing to provide their services in accordance with them. Second, they developed a *Peer Review Protocol*. Members must agree to subject themselves to a BCA peer review process if a client charges that their performance does not follow the *Attributes*. The last significant way that the organization ensures quality in the market place is through their Professional Development Program. This is a three-module training program. The first module targets potential members and commissioning customers by providing an introductory training on what quality commissioning entails. The second module (which is still under development) targets the membership and establishes a baseline of skills and conduct that exemplifies commissioning professional values. The third module (also still under development) again targets the membership and provides on-going technical support and links with new developments in the field.

PECI recommends that PG&E support the development of a BCA membership base in California to address the concerns regarding quality service delivery. At minimum, PG&E should consider funding at least one if not a series of informational meetings. These meetings would constitute a forum where the BCA president or executive director can present the organizational mission and goals in order to pique the interest of California commissioning providers in joining the BCA.

Educating owners about how to ask for and obtain quality commissioning services is also an important market strategy. As customers become more knowledgeable about how to obtain quality services, the quality of service will increase to meet the demand. PEGI recommends that PG&E develop more advanced training workshops for owners that address how owners can obtain quality services. The following lists some example workshop topics:

- ✍️ How to obtain an excellent commissioning provider (developing the RFQ and RFP)
- ✍️ What to expect a commissioning/retrocommissioning plan to encompass
- ✍️ Developing the scope of work
- ✍️ Controlling/managing the process

6. Issue: California may incorporate aspects of commissioning into code

Commissioning providers had mixed reactions to incorporating commissioning into the California Energy Code. Almost 50% thought that commissioning code requirements would be very effective in increasing commissioning services and about 40% thought they would be not effective or only somewhat effective. Some providers thought that code requirements would force owners to commission their buildings and as a result market demand for commissioning would increase. Others thought this scenario was unworkable because the code requirements would not be developed and enforced effectively.

Two-thirds of owners surveyed felt that commissioning code requirements would be an effective way to increase market demand. They assumed if it was in the code, they would have to do it. Only 10% of owners thought that code requirements would not be very effective in increasing market demand. However, they did not think code requirements were necessarily a good idea: a hammer that might create resentment.

Recommendations:

The California Energy Commission (CEC), in collaboration with PEGI and the New Buildings Institute (NBI) is currently performing a feasibility analysis for incorporating aspects of performance verification into the California Energy Code. The effort includes soliciting input from stakeholders

in California, developing recommendations on how to incorporate aspects of commissioning into the code, and presenting the results at two public review workshops. PEGI recommends that PG&E support current efforts by the CEC in developing commissioning code requirements.

The commissioning process is very thorough and varies between buildings. As a result, it would be impossible to fully integrate commissioning into the California Energy Code. The word commissioning should not be used in the code to avoid confusion between the code requirements and the full commissioning process. The term performance verification could be used instead.

Below we list ideas we feel should be considered when the code requirements are finalized. We feel they will address the concerns expressed by owners and providers.

- ✍✍The code requirements support the development of a commissioning industry that understands and advocates for a thorough, holistic commissioning process.
- ✍✍Performance verification requirements must ensure that a thorough commissioning process is occurring.
- ✍✍Performance verification requirements should be appropriate to building size and complexity.
- ✍✍Performance verification requirements must be tied to the building permit and/or final occupancy permits to ensure they are followed.
- ✍✍The performance verification requirements should not be completed by building inspectors. A certified performance verification specialist is needed to ensure that a thorough performance verification process is completed.
- ✍✍There must be an adequate number of performance verification specialists available to support the new performance verification code requirements.
- ✍✍Performance verification requirements should not create an unmanageable burden on owners, contractors, designers, and building officials.
- ✍✍Performance verification requirements should provide demonstrable benefits to owners besides energy savings and owners should be made aware of these benefits.

By providing the information necessary to follow and/or implement the commissioning code, PG&E could provide the support necessary to create the early success stories and momentum needed for effective enforcement. Below is a list of some of the areas where utility support may be needed:

- ✍✍To train performance verification specialists.
- ✍✍To provide workshops for owners on the commissioning process and the code requirements.
- ✍✍To provide workshops for code officials on the value and specifics on the new code requirements.

Additionally, PG&E could support owners who go beyond the code requirements. For example, PG&E could offer incentives to owners who implement more extensive performance verification testing and/or use a certified third party. This would be particularly helpful if the programs provided a trial run for future commissioning code requirements.

For more information on how commissioning code requirements could be phased into the code and how PG&E could support this process, we recommend that PG&E staff consider attending the public review hearing on Nov 13th in Sacramento.

7. Issue: Building owners need software and assessment tools

Survey respondents felt that owners are often not aware that their buildings have problems. In fact, many owners think that buildings built to spec perform correctly. Lack of budget was also consistently given as a very significant barrier to commissioning and retrocommissioning. Automated tools address both of these barriers by providing a means to automate commissioning (or retrocommissioning) procedures to reduce costs and by continuously identifying problems. Automated commissioning tools could help experienced and skilled facility staff troubleshoot and operate their buildings to the point where they are continuously commissioning their facilities.

When asked “what types of software or assessment tools that you don’t already use would benefit you in operating your building,” owners expressed a strong interest in automated diagnostic tools that could help them detect equipment and system problems. Respondents were largely unaware of all the new diagnostic equipment emerging in the market and instead described functions they would like to see incorporated into tools. Some are given below:

- ✍️Diagnostic systems that detect building problems.
- ✍️Real world software that shows how efficiency changes under various conditions.
- ✍️A light that indicates if a piece of equipment is on and if it should be on.
- ✍️Diagnostics that keep air flow in line with actual building needs.
- ✍️We’ve got vending machines that call for an operator when they need to be refilled. How about a refrigerator machine that tells us when the bearings are hot.
- ✍️Utility tracking software that tracks consumption in real time and flags operators when usage is above a certain level.
- ✍️An energy tracking program that provides an annual comparison of how much money was spent on utility bills versus what would have been spent if the space was designed and operated properly.
- ✍️A portable handheld system that can scan the barcode on any piece of equipment and bring up the whole service history.
- ✍️Software that would enable different manufacturers’ EMCS software to work together.

Owners also cited tools that they were familiar with. They were very interested in energy management control systems and EMCS software training. Respondents also said they would like to use the following tools: PG&E’s CoolTools, the Whole Building Diagnostician, and PACRAT.

Recommendations

In the last few years, a remarkable number of automated diagnostic tools have entered the commissioning market. Many automated diagnostic tools use data that is recorded using the building automation system and/or dataloggers to collect data and then use internal algorithms to detect and diagnose problems in equipment. Examples of such tools include the Performance and Continuous Re-Commissioning Analysis Tool (PACRAT), developed by Facility Dynamics Engineering, the Whole Building Diagnostician (WBD) developed by Pacific Northwest National Laboratory, and the ACRx Controller Palm Pilot based tools developed by Field Diagnostic Services. Owners are very interested in the capabilities of these tools and the tools have the potential to save significant energy.

PECI recommends that PG&E facilitate greater use of these tools by:

- ✍️Increasing marketing efforts to inform owners about these new tools.

- ✍✍ Providing financial incentives to owners to make these tools more affordable and/or increasing the tools' availability through the tool lending library. Two incentive methods to consider are customer rebates and manufacturer incentives.
- ✍✍ Supporting training on these new tools.

Some owners indicated a desire for tools that are even more advanced than the tools described above. For example, owners expressed an interest in tools that not only detect but also correct the problems. PECE recommends that PG&E consider:

- ✍✍ Supporting research and development of new diagnostic tools.
- ✍✍ Supporting companies that make innovative diagnostic tools with venture funding or partnerships.

8. Issue: Commissioning providers need software and assessment tools

Commissioning providers indicated that measuring devices, dataloggers, the energy management control system, and the universal translator were very important in determining whether equipment was performing according to the design intent. Flow meters and velometers were also mentioned by a couple of respondents as helpful. Though most of our survey respondents were already using these tools, it is likely that many novice commissioning providers in California would be interested in access to these tools or training on how to use them.

Commissioning providers are also clearly interested in automated tools. In fact, providers rated tools to decrease delivery time such as software tools, automated tools, and management tracking tools as a useful method for developing commissioning skills. Several diagnostic tools have been introduced into the market recently -- such as PACRAT, WBD and the ACRx controllers. However, most of these tools require a considerable amount of setup time to customize the tool for the building. As a result, these tools are better suited for owners rather than commissioning providers. However, there are some beginning efforts to develop tools that automate the commissioning process, such as Comit -- a new tool that automates the process of developing functional test procedures.

Almost one-third of respondents expressed an interest in process management software to automate and standardize tasks such as estimating commissioning costs. Some providers mentioned that this type of tool could also be used by owners to compare different proposals for commissioning projects. Tools mentioned that facilitate the organization and use of commissioning data include:

- ✍✍ An automated estimating form with checklist costing that comes up with a budget line item based on the commissioning tasks to be accomplished on a project
- ✍✍ A document control program to streamline the commissioning process between design documentation and functional testing documents
- ✍✍ An interactive program that allows drawings, O&M materials, and control point sequences to be put on the internet for easier access.

Recommendations

New commissioning providers may be hesitant to invest in commissioning tools and will certainly need training on how to use basic tools, including dataloggers, EMCS software, etc. The PG&E tool lending library is an excellent resource for new commissioning providers, and we recommend that PG&E continue this effort and increase awareness of the resource.

In addition, PG&E can take advantage of opportunities to support the development of new automated commissioning tools. Commissioning providers are very interested in the following types of commissioning tools:

- ✍✍ Tools that efficiently and effectively diagnose building problems without requiring extensive setup time.
- ✍✍ Tools that facilitate the development of functional testing procedures.
- ✍✍ Tools that facilitate commissioning process management.

We recommend that PG&E consider developing marketing efforts to let providers know about new tools as they are developed and to provide commissioning provider training on the new tools. In addition, PECO recommends that PG&E keep apprised of research and development efforts that will benefit commissioning providers and consider supporting the development of new tools with research and development and/or venture funding or partnerships.

The evolution of diagnostic tools will continue and we expect to see an ongoing need for marketing and training. PECO recommends that PG&E consider developing a package of technologies and services to meet the growing demand for help in operating and maintaining commercial buildings. This could possibly be done as a venture and could become a platform or franchise to support commissioning providers.

Conclusions

Building commissioning is a nascent industry with tremendous potential to increase the quality of the building delivery system. It is only over the last decade that the construction industry has begun to view building commissioning as a business opportunity and a way to ensure quality projects (two thirds of the vendors surveyed have offered the service for ten years or less).

The survey data clearly shows that there are several needs for PG&E to address that will positively impact the growth of the industry. The following lists the most significant:

- ✍✍ Industry-wide education on what commissioning and retrocommissioning entails and the resulting energy and non-energy benefits
- ✍✍ Better tools for diagnostics and analysis for both owners and providers
- ✍✍ Code development addressing performance verification
- ✍✍ Methods for ensuring a quality infrastructure (commissioning service delivery)

Of these, the need to educate owners is the foremost issue along with the need for case studies demonstrating the benefits of both commissioning and retrocommissioning. Once owners understand the benefits and are confident and sophisticated buyers of the service, the requests for commissioning will increase and the industry will mature in a quality manner.

Because much of the focus for both commissioning and retrocommissioning is on optimizing building performance that reduces energy waste, it is advantageous for PG&E support the industry with financial incentives, educational programs, methods for ensuring quality delivery, and research and development of tools and software that expedite the process.

Appendix A: Expanded Survey Tables

Appendix A contains the survey specific data for providers' and owners' past commissioning projects and future plans. The data in these tables is summarized in the body of the report.

Table P5.1: Commissioning as a Percentage of Business

Question 12 of the Provider Survey asked commissioning providers to indicate how much of their business is comprised of commissioning. In the table below, we have sorted the vendors by size of firm; it appears that firms focusing on commissioning tend to be smaller firms.

Table P5.1: Commissioning as a Percentage of Business

Survey Number	Number of Employees	What % of Business is Commissioning?
123	1	80
104	1	10
115	1	
116	1	40
106	1	20
112	1	30
102	2	5
101	4	30
124	4	97
107	5	30-35
122	7	3
120	8	15
117	16	70
121	22	7
103	30	10
119	35	5
114	35	80
113	40	15
108	40	2
111	52	2
109	80	2-3
118	90	1
105	150	3
110	320	10
125	600	1

Table C2.1: Construction and Renovation Completed

Question Three in the Customer survey asked owners to estimate the square feet of combined new construction and renovation completed in the past five years.

Table C2.1: Construction & Renovation Projects Completed in Past Five Years

Survey #	Approx. Square Feet Completed
201	276,000
202	1,000,000
203	1,000,000
204	1,000,000
205	600,000
206	1,000,000
207	800,000
209	2,000,000
211	Don't Know (dk)
212	1,750,000
213	850,000
215	2,500,000
216	850,000
217	dk
218	3,000,000
219	34,000
221	150,000
222	1,000,000
223	420,000
224	500,000
Total	18,730,000

Table C5.1: New Construction Plans

Question Seven of the Customer's survey asked owners to estimate the new construction plans for the next five years. Seventeen of the twenty-four interviewed are planning new projects.

Table C5.1: New Construction Planned within the Next Five Years

Survey #	Planned New Construction (Approx. Sq. Ft)
202	750,000
203	1,500,000
204	1,500,000
205	Don't Know (dk)
206	1,000,000
207	dk
210	60,000
211	3,000,000
212	dk
213	1,000,000
215	840,000
216	200,000
217	100,000
221	dk
222	475,000
223	dk
224	2,000,000
Total	11,585,000

Table C7.1: Planned Renovations

Question Ten of the Customer's survey asked owners to estimate renovations planned for the next five years.

Table C7.1: Renovations Planned within the Next Five Years

Survey #	Planned Renovations (Approx. Square Feet)
201	32,000
202	250,000
203	1,000,000
204	87,000
205	200,000
206	1,000,000
210	500,000
211	200,000
212	600,000
216	150,000
217	350,000
218	186,000
223	150,000
Total	4,705,000

Table C9.1: Percentage of Buildings Commissioned

By comparing owner responses to Question 15 (the number of projects that have involved commissioning) and Question 27 (the total number of buildings owned) we can estimate the percent of our owners' buildings that have been commissioned. (Keep in mind that six providers had no buildings commissioned because they were either not finished with the process, or had only experienced retrocommissioning.) The comparison suggests that approximately 9% of the owners' buildings have been commissioned. However, this figure includes two large owners with unusually high percentages. Number 208 operates university laboratories, and hires an outside agent on larger projects. Number 215 is a private owner who claims to do all commissioning in-house. If these two owners are eliminated from the survey, the resulting numbers indicate that closer to 3% of all buildings have been commissioned. This figure is probably more in line with figures for the California market as a whole.

Table C9.1: Percentage of Buildings Commissioned

Survey Number	Number of buildings owned in CA	Number of projects that have involved commissioning	Calculated percent of buildings commissioned
201	1		
202	300	6	2%
203	150	1	1%
204	100	4	4%
205	25		
206	400	2	1%
207	150	1	1%
208	200	100	50%
209	200	4	2%
210	100	1	1%
211	80	1	1%
212	50	5	10%
213	23	10	43%
214	NA		
215	243	120	49%
216	450	3	1%
217	150		
218	30		
219	50	1	2%
220	12	2	17%
221	9		
222	12	1	8%
223	300	1	0%
224	15	all	
TOTALS	3049	278	9%

Tables C10.1, C10.2: Recent Commissioning Projects

Question 16 of the Customer's survey asked owners to describe their recent commissioning projects. We have created two tables to view the data sorted by building type and by survey number.

Table C10.1: Recent Commissioning Projects: Sorted by Building Type

Survey #	Building	Type	Year Cxed	Approx. Sq. Ft.	\$ to Commission	Project Type	Total Sq. Ft.
210	Office	Commercial	1994	16,000		N	
215	Office	Commercial	1999	330,000	\$115,850	RN	
215	Office	Commercial	1999	330,000	\$115,850	RN	
215	Office	Commercial	2000	240,000	\$80,900	RN	
219	Heart Center	Commercial	1998	34,000	dk	N	
222	Office	Commercial		1,000,000			
224	Mid rise	Commercial	1998	170,000		N	
224	Mid rise	Commercial	1999	110,000		N	
224	Mid rise	Commercial	2000	150,000		N	2,380,000
203	Jail	Govt.	99	150,000		N	
206	Library	Govt.	1993	250,000	dk	N	
206	Courthouse	Govt.	1997	250,000	\$104,000	N	
207	Courthouse	Govt.	1997-98	250,000	dk	N	
209	Courthouse	Govt.	1998	500,000	dk	N	
209	Courthouse	Govt.	1998	500,000	dk	N	
209	Office	Govt.	1998	1,200,000	dk	RN	
211	Hospital	Govt.	2000		\$400,000	N	
212	Office	Govt.	2000	500,000	DK	N	
212	Office	Govt.	2000	500,000	DK	N	
212	Office	Govt.	2000	500,000	DK	N	
213	Police Facility	Govt.	1997	30,000	\$40,000	N	
216	High School	Govt.	1999	200,000	\$40,000	N	
216	High School	Govt.	1999	89,000	\$20,000	RN	
216	High School	Govt.	1999	170,000	\$35,000	RN	
220	Train Station	Govt.	1990	dk	dk	N	
220	City Hall	Govt.	1989	dk	dk	N	
223	Admin	Govt.	1998	420,000	Dk	N	5,509,000
202	Art Museum	Govt. University	2000	30,000	\$5000		
202	Office/Labs	Govt. University	2000	dk		N	
204	Lab	Govt. University	98-00	90,000	1% of total	N	
204	Lab/Office	Govt. University	98-00	70,000	1% of total	N	
204	Haz Mat Storage	Govt. University	98-00	125,000	1% of total	N	
208	Computer Lab	Govt. University	2000	15,000	\$30,000	N	
208	Lab	Govt. University	1999	60,000	dk	RN	
213	Office	Govt. University	1997	115,000	\$25,000	N	
213	Library	Govt. University	1997	130,000	\$60,000	N	635,000
Total				8,524,000			8,524,000

Project type includes New (N) and Renovation (RN)

Table C10.2: Recent Projects Sorted by Survey Number

Survey #	Building	Type	Year Cxed	Approx. Sq. Feet	\$ to Commission	Project Type
202	Art Museum	Govt. University	2000	30,000	\$5,000	
202	Office/Labs	Govt. University	2000	dk	dk	N
203	Jail	Govt.	99	150,000	dk	N
204	Lab	Govt. University	98-00	90,000	1% of total	N
204	Lab/Office	Govt. University	98-00	70,000	1% of total	N
204	Haz Mat Storage	Govt. University	98-00	125,000	1% of total	N
206	Library	Govt.	1993	250,000	dk	N
206	Courthouse	Govt.	1997	250,000	\$104,000	N
207	Courthouse	Govt.	1997-98	250,000	dk	N
208	Computer Facility	Govt. University	2000	15,000	\$30,000	N
208	Lab	Govt. University	1999	60,000	dk	RN
209	Courthouse	Govt.	1998	500,000	dk	N
209	Courthouse	Govt.	1998	500,000	dk	N
209	Office	Govt.	1998	1,200,000	dk	RN
210	Office	Commercial	1994	16,000	dk	N
211	Hospital	Govt.	2000	dk	\$400,000	N
212	Office	Govt.	2000	500,000	dk	N
212	Office	Govt.	2000	500,000	dk	N
212	Office	Govt.	2000	500,000	dk	N
213	Police Facility	Govt.	1997	30,000	\$40,000	N
213	Office	Govt. University	1997	115,000	\$25,000	N
213	Library	Govt. University	1997	130,000	\$60,000	N
215	Office	Commercial	1999	330,000	\$115,850	RN
215	Office	Commercial	1999	330,000	\$115,850	RN
215	Office	Commercial	2000	240,000	\$80,900	RN
216	High School	Govt.	1999	200,000	\$40,000	N
216	High School	Govt.	1999	89,000	\$20,000	RN
216	High School	Govt.	1999	170,000	\$35,000	RN
219	Heart Center	Commercial	1998	34,000	dk	N
220	Train Station	Govt.	1990	dk	dk	N
220	City Hall	Govt.	1989	dk	dk	N
222	Office	Commercial		1,000,000		
223	Admin	Govt.	1998	420,000	dk	N
224	Mid rise	Commercial	1998	170,000		N
224	Mid rise	Commercial	1999	110,000		N
224	Mid rise	Commercial	2000	150,000		N
Total:				8,524,000		

Appendix B: Estimated Cost and Savings Tables

The following tables present the detailed estimates of costs and savings for commissioning activity in California.

Table B-1. Commissioning Market Potential - Existing Buildings

For All of California and Only For Buildings > 25,000 sf

Sector	A	B	C		D	E	F	G	H	I	J	K	L	M
	Energy Savings Fraction	Total Cost of Cx and Fixes (\$/sf)	> 25k sf		Total Floor Area (millions of sf)	Site Energy Use Index (kBtu/sf/yr)	Commissioning (Existing Equipment)							\$/kWh Saved
			Tot Num. of Bldgs in Calif				Annual Penetration Rate	Area Commissioned (1000's sf/yr)	Annual Energy Savings (Millions of kBtu)	Annual Energy Dollar Savings (Millions)	Cx Cost (Millions)	Payback From Energy Alone (yrs)	Needed Commissioning Consultant FTE	
Office	0.15	\$ 0.34	8494		722	68	0.020	14,440	146.5	\$ 2.45	\$ 4.91	2.0	47	0.114
Restaurant	0.10	\$ 0.32	0		0	332	0.020	-	0.0	\$ -	\$ -	n/a	0	
Retail	0.15	\$ 0.32	5419		395	92	0.020	7,907	108.8	\$ 1.56	\$ 2.53	1.6	26	0.079
Grocery	0.12	\$ 0.33	2039		102	209	0.020	2,039	51.2	\$ 0.96	\$ 0.67	0.7	7	0.045
School	0.15	\$ 0.34	9517		558	59	0.020	11,167	98.0	\$ 1.20	\$ 3.80	3.2	36	0.132
College	0.15	\$ 0.33	691		226	100	0.020	4,529	68.2	\$ 0.78	\$ 1.49	1.9	15	0.075
Hospital	0.15	\$ 0.47	2451		269	209	0.020	5,374	168.7	\$ 1.91	\$ 2.53	1.3	22	0.051
Lodging	0.15	\$ 0.34	2432		195	82	0.020	3,909	48.1	\$ 0.64	\$ 1.33	2.1	13	0.094
All Buildings			31,043		2,468			49,365	690	\$ 9.51	\$ 17.26	1.8	165	0.085

Shaded column heads denote columns of input or inputs pulled from another table. Other columns are calculated.

Column Formula and Notes

A Energy savings fraction of total energy use: Based on PECl estimates by building type for commissioning for low-cost operational type measures. Correlates well with the literature that shows 10-30% typical savings.

B Costs include commissioning provider's labor, facility staff time involvement and cost of fixes. Refer to Table B-8a for full details. Per sf costs may be considerably higher for buildings smaller than the average and lower for larger buildings.

C Total number of buildings in each sector in California >25,000 sf. From Table B-5.

D Total floor area in buildings >25,000 sf from Table B-5.

E Total energy use for sector by adding average elec and gas consumption from Table B-7b. Source PG&E averages are being used for the entire state.

F Quantity of sf commissioned annually. This is an adjustable estimate.

G $F \times D \times 1000$

H $D \times E \times A \times F$

I $H \times G$ of Tbl B-7b

J $D \times F \times B$

K J / I

L $(F \times 1,000,000 \times \text{Col B of Tbl B-8a} / \text{salary from Tbl B-8a}) \times F$

M Dollars saved / Btu's saved converted to kWh. This is a one time cost for these annual savings.

Table B 2. Commissioning Market Potential – New Construction

For All of California and Only For Buildings > 25,000 sf

	A	B	C	D	E	F	G	H	I	J	K	L	M
			> 25k sf			Commissioning (New Construction)							
Sector	Energy Savings Fraction	Total Cost of Cx In Design and Const (\$/sf)	Tot Num. of New Bldgs in Calif	Total New Const. Floor Area (millions of sf)	Site Energy Use Index (kBtu/sf/yr)	Annual Penetration Rate	Area Commissioned (1000's sf/yr)	Annual Energy Savings (Millions of kBtu)	Annual Energy Dollar Savings (Millions)	Cx Cost (Millions)	Payback From Energy Alone (yrs)	Needed Commissioning Consultant FTE	\$/kWh Saved
Office	0.09	\$ 1.07	254	21.56	68	0.30	6,468	39.4	\$ 0.66	\$ 6.89	10.5	61	0.597
Restaurant	0.06	\$ 1.72	0	0.00	332	0.30	-	0.0	\$ -	\$ -	n/a	0	
Retail	0.09	\$ 1.07	141	10.28	92	0.30	3,085	25.5	\$ 0.37	\$ 3.29	9.0	29	0.440
Grocery	0.07	\$ 1.59	56	2.78	209	0.30	833	12.2	\$ 0.23	\$ 1.33	5.8	12	0.371
School	0.09	\$ 1.20	196	11.51	59	0.30	3,454	18.2	\$ 0.22	\$ 4.13	18.5	37	0.775
College	0.09	\$ 0.87	12	3.77	100	0.30	1,131	10.2	\$ 0.12	\$ 0.98	8.4	8	0.328
Hospital	0.09	\$ 1.35	55	5.98	209	0.30	1,795	33.8	\$ 0.38	\$ 2.43	6.4	21	0.245
Lodging	0.06	\$ 1.00	68	5.45	82	0.30	1,636	8.1	\$ 0.11	\$ 1.63	15.3	14	0.692
All Buildings			780	61.35			18,404	147	\$ 2.08	\$ 20.68	9.9	182	0.479

Shaded column heads denote columns of input or inputs pulled from another table. Other columns are calculated.

Column Formula and Notes

- A Energy savings fraction of total energy use: Based on PECE estimates by building type for commissioning in the design phase and construction phase. The savings come from no-cost recommendations to improve or remedy oversights and deficiencies during design and during construction for improvements that would not have been realized without commissioning.
- B Costs include the costs of the commissioning provider, designer, contractor and owner staff during the design and construction phases. Per sf costs may be considerably higher for buildings smaller than the average and lower for larger buildings. See Table B-8b for details
- C Total number of buildings being added assuming all are the average size of the groups in Table B-5. Includes only those > 25,000 sf. Source is from Table B-6.
- D Total floor area in new construction for buildings >25,000 sf from Table B-6. It does not include remodels or renovations.
- E Total energy use for sector by adding average elec and gas consumption from Table B-7b. Source PG&E averages are being used for the entire state.
- F Quantity of sf commissioned annually. This is an adjustable estimate.
- G $F \times D \times 1000$
- H $D \times E \times A \times F$
- I $H \times G$ of Tbl B-7b
- J $D \times F \times B$
- K J / I
- L $(F \times 1,000,000 \times \text{Col B of Tbl B-8b} / \text{salary from Tbl B-8b}) \times F$
- M Dollars saved / Btu's saved converted to kWh. This is a one time cost for these annual savings.

Table B-3. California Floor Space Projections – All Utilities; All Climate Zones

Year	(millions of sf)		LRG-OFF.		TOTAL OFFICE		RESTAUR.		RETAIL		FOODSTR		ELEM SCH		UNIV/COL
	SML-OFF.		STOCK	ADDITIO	STOCK	ADDITIO	STOCK	ADDITIO	STOCK	ADDITIO	STOCK	ADDITIO	STOCK	ADDITIO	
1990	313.56	10.386	904.223	36.368	1217.783	46.754	130.776	3.899	755.378	28.342	198.744	6.929	391.563	6.404	238.222
1991	321.66	9.79	928.958	28.682	1250.618	38.472	133.879	3.696	780.727	30.598	205.185	7.922	397.619	6.87	242.654
1992	326.344	6.541	943.662	19.072	1270.006	25.613	135.942	2.743	797.355	22.275	209.392	5.808	403.943	7.217	245.348
1993	329.814	5.46	948.669	9.159	1278.483	14.619	137.099	1.931	812.23	20.884	213.52	5.839	409.181	6.221	249.084
1994	332.659	4.855	950.856	6.652	1283.515	11.507	138.05	1.716	821.877	16.057	215.925	4.232	415.126	7.013	253.105
1995	334.511	3.842	951.975	5.642	1286.486	9.484	138.728	1.464	831.386	15.784	218.322	4.182	422.255	8.321	256.01
1996	336.28	3.981	954.009	6.618	1290.289	10.599	139.561	1.709	838.958	14.065	220.181	3.708	425.987	4.978	259.049
1997	340.513	3.548	965.722	9.944	1306.235	13.492	140.154	1.986	847.248	15.592	222.126	3.951	431.18	4.63	261.114
1998	346.242	13.188	981.561	36.73	1327.803	49.918	141.236	2.36	854.671	17.426	224.156	4.951	439.484	11.884	263.667
1999	353.357	10.289	1001.668	28.318	1355.025	38.607	142.939	2.998	868.608	22.418	227.354	5.618	448.875	11.093	266.951
2000	361.027	11.025	1024.28	31.449	1385.307	42.474	145.17	3.629	882.35	22.596	230.52	5.691	457.468	10.452	270.127
2001	368.795	11.301	1046.97	32.171	1415.765	43.472	147.519	3.853	896.165	23.024	234.414	6.517	465.851	10.412	273.337
2002	376.436	11.336	1069.619	32.763	1446.055	44.099	149.791	3.879	910.554	23.931	238.083	6.382	474.117	10.474	276.603
2003	383.909	11.318	1091.625	32.746	1475.534	44.064	151.982	3.905	924.748	24.054	241.88	6.592	481.65	9.933	279.867
2004	391.138	11.213	1112.693	32.416	1503.831	43.629	154.111	3.946	938.739	24.145	245.657	6.648	489.079	10.036	283.118
2005	398.062	11.027	1133.158	32.393	1531.22	43.42	156.191	3.997	952.596	24.282	249.374	6.652	496.108	9.857	286.322
2006	404.633	10.781	1152.433	31.746	1557.066	42.527	158.202	4.022	965.856	23.94	252.97	6.594	502.552	9.501	289.442
2007	411.06	10.731	1171.338	31.882	1582.398	42.613	160.151	4.054	977.749	22.806	256.339	6.418	508.77	9.52	292.343
2008	417.618	10.941	1190.867	32.971	1608.485	43.912	162.129	4.166	989.583	22.97	259.698	6.457	514.347	9.134	295.152
2009	424.224	11.065	1210.715	33.701	1634.939	44.766	164.156	4.296	1002.734	24.497	263.296	6.738	519.319	8.796	298.083
2010	430.869	11.168	1231.128	34.632	1661.997	45.8	166.209	4.393	1015.968	24.782	266.907	6.792	523.618	8.402	300.995

Source:

The above data is a direct copy from the file received on 10/10/00 from Tav Cummins of CEC: flsfc_by_zone_1.xls, with the title: "Used for forecast in: California Energy Demand, 2000-2010, Publication # 200-00-002. July 14, 2000". The source table had the values broken out by climate zone and by utility. Just the totals are shown in the above table. Also, the large and small office were summed into the Total office columns.

Fractional increase from 2000 to 2010:

0.16	0.01	0.17	0.09	0.17	0.07	0.13	0.17	0.13	0.09	0.14	0.16	0.13	-0.24	0.10
Average sf added annually from 2000 to 2010 (millions):														
	11.08		32.62		43.71		4.01		23.73		6.50		9.68	

Observations:

For existing stock, the increase from 2000 to 2010 is only 10-17%, which is not much, so using the stock at 2003 provides a reasonable value for all years over the next 10 years.

Table B-3. (Continued) California Floor Space Projections – All Utilities; All Climate Zones

	(millions of sf)												
	HOSPITAL			HTL/MTL		NRFGWH		REFGWH		MISCELL.		TOTAL	
Year	ADDITION	STOCK	ADDITIONS	STOCK	ADDITION	STOCK	ADDITION	STOCK	ADDITION	STOCK	ADDITION	STOCK	ADDITION
1990	4.756	226.035	9.467	242.48	8.186	637.499	31.603	33.589	1.019	850.154	31.437	4922.224	178.798
1991	4.905	234.656	9.042	248.954	8.097	661.753	30.001	35.145	1.742	872.507	26.299	5063.698	167.646
1992	3.186	240.545	6.344	253.593	6.378	675.009	19.058	35.892	1.027	889.994	21.825	5157.016	121.475
1993	4.332	245.515	5.475	253.964	1.364	682.826	11.717	37.192	1.791	906.207	20.972	5225.297	95.139
1994	4.617	251.17	6.203	253.953	0.612	687.505	7.43	38.051	1.431	917.341	16.341	5275.62	77.158
1995	3.473	255.907	5.294	254.002	0.791	691.293	6.672	39.858	2.466	924.349	11.917	5318.598	69.849
1996	3.748	258.458	3.145	254.079	1.417	696.625	9.537	40.368	0.864	934.12	15.501	5357.674	69.278
1997	2.229	264.134	5.742	256.989	1.463	703.13	10.735	41.185	1.033	946.331	12.953	5419.826	73.803
1998	4.329	268.927	6.306	260.904	14.872	712.557	35.718	41.614	2.278	960.654	28.697	5495.672	178.743
1999	4.274	273.718	5.63	265.943	7.685	727.444	23.201	42.272	1.237	977.13	24.259	5596.26	147.022
2000	4.261	278.574	5.763	270.872	7.67	744.502	25.545	42.928	1.246	992.522	23.726	5700.34	153.057
2001	4.389	282.997	5.408	275.803	7.772	761.961	26.098	43.81	1.482	1007.832	24.201	5805.456	156.623
2002	4.554	288.042	6.105	280.787	7.919	778.821	25.606	44.593	1.391	1022.875	24.492	5910.319	158.828
2003	4.661	293.433	6.535	285.744	7.972	795.13	25.137	45.399	1.413	1037.987	25.103	6013.35	159.367
2004	4.771	298.342	6.139	290.618	7.964	810.965	24.706	46.19	1.401	1052.834	25.367	6113.487	158.748
2005	4.851	303.5	6.482	295.469	8.005	826.272	24.192	46.974	1.392	1067.491	25.687	6211.518	158.818
2006	4.9	308.936	6.851	300.104	7.846	840.989	23.602	47.733	1.361	1081.722	25.741	6305.574	156.885
2007	4.821	313.817	6.394	304.289	7.448	855.331	23.208	48.451	1.314	1095.059	25.299	6394.699	153.896
2008	4.877	319.542	7.336	308.301	7.316	869.884	23.392	49.171	1.308	1107.821	25.135	6484.114	156.001
2009	5.152	325.346	7.516	312.552	7.594	884.665	23.591	49.931	1.34	1120.95	25.884	6575.973	160.172
2010	5.292	333.597	10.068	316.784	7.609	899.571	23.686	50.7	1.342	1134.038	26.179	6670.386	164.346
	0.19	0.16	0.43	0.14	-0.01	0.17	-0.08	0.15	0.07	0.12	0.09	0.15	0.07
	4.78		6.78		7.74		24.43		1.36		25.16		157.89

Table B-4. PG&E Market Characterization – Building Sector Floor Areas

PG&E Territory Only Existing Buildings

A	B	C	D	E			F			G			H		
Avg sf for Range----				500			1,500			2,500			7,500		
Building Type	Thousands of Square Feet	Thousands of Square Feet	Customers	0-1000 sq ft.			1,001-2,000 sq ft.			2,001-5,000 sq ft.			5,001-10,000 sq ft.		
	(by PG&E) [1]	(by CEC) [2]		% of Bldgs	# Bldgs	% of Tot Sq Ft	% of Bldgs	# Bldgs	% of Tot Sq Ft	% of Bldgs	# Bldgs	% of Tot Sq Ft	% of Bldgs	# Bldgs	% of Tot Sq Ft
Office	631,620	434,436	90,900	25	22,725	1.8	28	25,452	6.0	18	16,362	6.5	16	14,544	17.3
Restaurants	61,030	43,828	25,300	20	5,060	4.1	31	7,843	19.3	39	9,867	40.4	9	2,277	28.0
Retail	273,680	315,081	72,900	36	26,244	4.8	29	21,141	11.6	18	13,122	12.0	8	5,832	16.0
Grocery	53,150	86,174	12,800	24	3,072	2.9	49	6,272	17.7	14	1,792	8.4	8	1,024	14.4
Schools	147,480	175,596	4,700	4	188	0.1	0	0	0.0	0	0	0.0	10	470	2.4
Colleges	60,710	105,034	600	0	0	0.0	45	270	0.7	15	90	0.4	0	0	0.0
Hospitals	58,670	10,823	1,400	25	350	0.3	15	210	0.5	0	0	0.0	5	70	0.9
Lodging	86,350	98,077	3,500	0	0	0.0	0	0	0.0	15	525	1.5	38	1,330	11.6
Refr Warehouse	27,600	22,539	1,000	2	20	0.0	2	20	0.1	15	150	1.4	21	210	5.7
Warehouse	220,750	247,524	23,600	23	5,428	1.2	16	3,776	2.6	8	1,888	2.1	19	4,484	15.2
Miscellaneous	143,590	37,604	40,600	34	13,804	4.8	4	1,624	1.7	47	19,082	33.2	7	2,842	14.8
Total	1,764,630	1,576,716	277,300												

Avg sf for Range----				17,500			37,500			75,000					
Building Type	Thousands of Square Feet	Thousands of Square Feet	Customers	10,001-25,000 sq ft.			25,001-50,000 sq ft.			50,001-100,000 sq ft.			100,001 & up sq ft.		
	(by PG&E) [1]	(by CEC) [2]		% of Bldgs	# Bldgs	% of Tot Sq Ft	% of Bldgs	# Bldgs	% of Tot Sq Ft	% of Bldgs	# Bldgs	% of Tot Sq Ft	% of Bldgs	# Bldgs	% of Tot Sq Ft
Office	631,620	434,436	90,900	8	7,272	20.1	2	1,818	10.8	1	909	10.8	1	909	27.3
Restaurants	61,030	43,828	25,300	1	253	7.3	0	0	0.0	0	0	0.0	0	0	0.0
Retail	273,680	315,081	72,900	7	5,103	32.6	1	729	10.0	0.6	437	12.0	0.6	437	20.8
Grocery	53,150	86,174	12,800	3	384	12.6	3	384	27.1	0.3	38	5.4	0.2	26	9.6
Schools	147,480	175,596	4,700	25	1,175	13.9	47	2,209	56.2	5	235	12.0	10	470	47.8
Colleges	60,710	105,034	600	15	90	2.6	5	30	1.9	0	0	0.0	20	120	79.1
Hospitals	58,670	10,823	1,400	20	280	8.4	9	126	8.1	16	224	28.6	10	140	54.9
Lodging	86,350	98,077	3,500	27	945	19.2	9	315	13.7	6	210	18.2	6	210	36.5
Refr Warehouse	27,600	22,539	1,000	29	290	18.4	16	160	21.7	4	40	10.9	10	100	43.5
Warehouse	220,750	247,524	23,600	20	4,720	37.4	10	2,360	40.1	4	944	32.1	1	236	12.8
Miscellaneous	143,590	37,604	40,600	6	2,436	29.7	2	812	21.2	1	406	21.2	0	0	0.0
Total	1,764,630	1,576,716	277,300												

Column Formula and Data Source Key

B From PG&E Commercial Building Survey Report 1999, Table 1.

C From the file received on 10/10/00 from Tav Cummins of CEC: flsps_by_zone_1.xls, with the title: "Used for forecast in: California Energy Demand, 2000-2010, Publication # 200-00-002. July 14, 2000". The source table had the values broken out by climate zone and by utility. Just the totals are shown in the above table. Also, the large and small office were summed into the Total office columns. The values shown in the above table are not used elsewhere in this table. Only the PG&E source numbers are used.

D From PG&E Commercial Building Survey Report 1999, Table 1.

E From PG&E Commercial Building Survey Report 1999, Table 3.

F (E / 100) x D

G 100 x F x avg sf in range in col. E / (B x 1000)

[1] We don't know the distribution of the number of buildings within a given size range. We assume it is evenly distributed. We don't even know the top end of the last range (> 100k sf). Therefore we had to make assumptions for the average sizes in the > 100k sf range. This column represents that. We adjusted this number in each sector until it resulted in the total floor area computed from the sum of all the # of buildings (generated from the % of Bldgs Col E) x the average floor area was close to the known area for the in the entire sector in Col B. In the retail and grocery sectors adjusting this average sf assumption for the > 100k group did not satisfactorily calibrate the two total sector floor areas, so the actual % of Bldgs values were altered (Col E) in the 50k to 100k and > 100k groups. Retail was changed from 1% in 50-100k and > 100k to 0.6% and Grocery was changed from 0% in both groups to 0.3% and 0.2%. This effort was trying to bring the data into a believable range, but illustrates the approximate nature of the data as a whole. The use of this report is to view trends for which approximate data is sufficient.

Sector	Avg. SF in > 100k Range [1]
Office	190000
Restaurants	0
Retail	130000
Grocery	200000
Schools	150000
Colleges	400000
Hospitals	230000
Lodging	150000
Refr Warehouse	120000
Warehouse	120000
Miscellaneous	0

Table B-5 (part 1) Existing Building Sector Floor Area – California Market Characterization

For All of

A		B	C	F				F				F			
		Avg sf for Range---->		500				1,500				2,500			
Building Type	Thousands of Square Feet	Thousands of Square Feet	PGE only (by PGE)--FYI	0-1000 sq ft				1,001-2,000 sq ft				2,001-5,000 sq ft			
				% of Bldgs	# Bldgs	Total SF (1000's)	% of Tot Sq Ft	% of Bldgs	# Bldgs	Total SF (1000's)	% of Tot Sq Ft	% of Bldgs	# Bldgs	Total SF (1000's)	% of Tot Sq Ft
Office	1,475,534	631,620		25	53,088	26,544	1.8	28	59,459	89,188	6.0	18	38,223	95,559	6.5
Restaurants	151,982	61,030		20	12,601	6,300	4.1	31	19,531	29,297	19.3	39	24,572	61,429	40.4
Retail	924,748	273,680		36	88,677	44,338	4.8	29	71,434	107,151	11.6	18	44,338	110,846	12.0
Grocery	241,880	53,150		24	13,980	6,990	2.9	49	28,543	42,815	17.7	14	8,155	20,388	8.4
Schools	481,650	147,480		4	614	307	0.1	0	-	0	0.0	0	-	0	0.0
Colleges	279,867	60,710		0	-	0	0.0	45	1,245	1,867	0.7	15	415	1,037	0.4
Hospitals	293,433	58,670		25	1,750	875	0.3	15	1,050	1,575	0.5	0	-	0	0.0
Lodging	285,744	86,350		0	-	0	0.0	0	-	0	0.0	15	1,737	4,343	1.5
Refr Warehouse	45,399	27,600		2	33	16	0.0	2	33	49	0.1	15	247	617	1.4
Warehouse	795,130	220,750		23	19,551	9,776	1.2	16	13,601	20,401	2.6	8	6,800	17,001	2.1
Miscellaneous	1,037,987	143,590		34	99,787	49,893	4.8	4	11,740	17,609	1.7	47	137,940	344,851	33.2
Total	6,013,354	1,764,630			290,082	145,041			206,636	309,954			262,429	656,071	

Table B-5 (Part 2) Existing Building Sector Floor Area – California Market Characterization

For All of California							>25,000 sf used in this study							
A			B		C		E		F		G		H	
			Avg sf for Range		17,500		37,500			75,000			See Note [3]	
Building Type	Thousands of Square Feet	Thousands of Square Feet PGE only (by (all of Calif) PGE)--FYI	10,001-25,000 sq ft				25,001-50,000 sq ft				50,001-100,000 sq ft			
			% of Bldgs	# Bldgs	Total SF (1000's)	% of Tot Sq Ft	% of Bldgs	# Bldgs	Total SF (1000's)	% of Tot Sq Ft	% of Bldgs	# Bldgs	Total SF (1000's)	% of Tot Sq Ft
Office	1,475,534	631,620	8	16,988	297,293	20.1	2	4,247	159,264	10.8	1	2,124	159,264	10.8
Restaurants	151,982	61,030	1	630	11,026	7.3	0	-	0	0.0	0	-	0	0.0
Retail	924,748	273,680	7	17,243	301,748	32.6	1	2,463	92,372	10.0	0.6	1,478	110,846	12.0
Grocery	241,880	53,150	3	1,748	30,582	12.6	3	1,748	65,533	27.1	0.3	175	13,107	5.4
Schools	481,650	147,480	25	3,837	67,154	13.9	47	7,214	270,536	56.2	5	767	57,561	12.0
Colleges	279,867	60,710	15	415	7,261	2.6	5	138	5,186	1.9	0	-	0	0.0
Hospitals	293,433	58,670	20	1,400	24,507	8.4	9	630	23,632	8.1	16	1,120	84,024	28.6
Lodging	285,744	86,350	27	3,127	54,725	19.2	9	1,042	39,089	13.7	6	695	52,119	18.2
Refr Warehouse	45,399	27,600	29	477	8,348	18.4	16	263	9,869	21.7	4	66	4,935	10.9
Warehouse	795,130	220,750	20	17,001	297,521	37.4	10	8,501	318,772	40.1	4	3,400	255,018	32.1
Miscellaneous	1,037,987	143,590	6	17,609	308,165	29.7	2	5,870	220,118	21.2	1	2,935	220,118	21.2
Total	6,013,354	1,764,630		80,476	1,408,329			32,117	1,204,372			12,760	956,991	

Data Source:

[1] PG&E Commercial Building Survey Report 1999. The number of customers in Table B-3 and the % of premises in Table B-5 were used to develop the % of total square footage in this table.

[2] From the file received on 10/10/00 from Tav Cummins of CEC: flsfc_by_zone_1.xls, with the title: "Used for forecast in: California Energy Demand, 2000-2010, Publication # 200-00-002. July 14, 2000". The source table had the values broken out by climate zone and by utility. Just the totals are shown in the above table. Also, the large and small office were summed into the Total office column. The values shown in the above table are not used elsewhere in this table. Only the PG&E source numbers are used.

[3] See Note [1] on Table B-4 for special note and list of average areas used for the sectors in this category.

Column Formula Key:

B 1000's of SF for All of Calif: CEC projection for 2003 from Table B-3.

C 1000's of SF for PG&E by PG&E for 2000 from Table B-4. Used in this table for reference of the magnitude of PG&E's bldgs to all of Calif.

E % of Buildings: This was developed from earlier spreadsheet for PG&E territory (Table B-4) and fixed here for all of Calif.

F # of Buildings: Calculated from: [G x 1000 / E]

G Total SF in thousands: This was calculated from the % of Tot SF and the Total SF. [H x B/100]

H % of Total Sq Ft.: This was developed from earlier spreadsheet for PG&E territory (Table B-4) and fixed here and used to calculate Total SF in this size range for all of California.

I The average sf above 25,000 sf is calculated from Table B-4 but is not considered a very reliable number.

Totals for > 25,000 sf			
Sector	Tot SF (1000's)	# Bldgs	Avg sf
Office	721,998	8,494	85,000
Restaurants	0	-	-
Retail	395,351	5,419	72,955
Grocery	101,940	2,039	50,000
Schools	558,341	9,517	58,669
Colleges	226,461	691	327,500
Hospitals	268,701	2,451	109,643
Lodging	195,446	2,432	80,357
Ref Warehouse	34,543	493	70,000
Warehouse	675,797	12,751	53,000
Misc	440,235	8,805	50,000
Total	3,618,814	53,092	68,161

Table B-6 (Part 1) New Construction Floor Area – California Market Characterization

For All of California

Includes new construction on new sites and new construction from replaced buildings. **Does not include renovations.**

Avg sf for Range---->		500				1,500				2,500			
Building Type	Thousands of SF of New Const. (all of Calif)	0-1000 sq ft.				1,001-2,000 sq ft.				2,001-5,000 sq ft.			
		% of Bldgs	# Bldgs	Total SF (1000's)	% of Tot Sq Ft	% of Bldgs	# Bldgs	Total SF (1000's)	% of Tot Sq Ft	% of Bldgs	# Bldgs	Total SF (1000's)	% of Tot Sq Ft
Office	44,064	25	1,585	793	1.8	28	1,776	2,663	6.0	18	1,141	2,854	6.5
Restaurants	3,905	20	324	162	4.1	31	502	753	19.3	39	631	1,578	40.4
Retail	24,054	36	2,307	1,153	4.8	29	1,858	2,787	11.6	18	1,153	2,883	12.0
Grocery	6,592	24	381	191	2.9	49	778	1,167	17.7	14	222	556	8.4
Schools	9,933	4	13	6	0.1	0	-	0	0.0	0	-	0	0.0
Colleges	4,661	0	-	0	0.0	45	21	31	0.7	15	7	17	0.4
Hospitals	6,535	25	39	19	0.3	15	23	35	0.5	0	-	0	0.0
Lodging	7,972	0	-	0	0.0	0	-	0	0.0	15	48	121	1.5
Refr Warehouse	1,413	2	1	1	0.0	2	1	2	0.1	15	8	19	1.4
Warehouse	25,137	23	618	309	1.2	16	430	645	2.6	8	215	537	2.1
Miscellaneous	25,103	34	2,413	1,207	4.8	4	284	426	1.7	47	3,336	8,340	33.2
Total	159,369												

Avg sf for Range---->		7,500				17,500			
Building Type	Thousands of SF of New Const. (all of Calif)	5,001-10,000 sq ft.				10,001-25,000 sq ft.			
		% of Bldgs	# Bldgs	Total SF (1000's)	% of Tot Sq Ft	% of Bldgs	# Bldgs	Total SF (1000's)	% of Tot Sq Ft
Office	73	16	1,015	7,610	17.3	8	507	8,878	20.1
Restaurants	174	9	146	1,093	28.0	1	16	283	7.3
Retail	88	8	513	3,844	16.0	7	449	7,849	32.6
Grocery	162	8	127	953	14.4	3	48	833	12.6
Schools	-244	10	32	237	2.4	25	79	1,385	13.9
Colleges	195	0	-	0	0.0	15	7	121	2.6
Hospitals	428	5	8	58	0.9	20	31	546	8.4
Lodging	-8	38	123	921	11.6	27	87	1,527	19.2
Refr Warehouse	72	21	11	81	5.7	29	15	260	18.4
Warehouse	-78	19	511	3,829	15.2	20	537	9,406	37.4
Miscellaneous	94	7	497	3,726	14.8	6	426	7,453	29.7
Total	954							38,540	

Table B-6 (Part 2) New Construction Floor Area – California Market Characterization

For All of California

Includes new construction on new sites and new construction from replaced buildings. **Does not include renovations.**

		>25,000 sf used in this study													
A	B	E				F				G				H	
Avg sf for Range---->		37,500				75,000				See Note [3]					
Building Type	Thousands of SF of New Const.	25,001-50,000 sq ft.				50,001-100,000 sq ft.				100,001 & up sq ft.				Ava. SF in > 100k sf Range [3]	
	(all of Calif)	% of Bldgs	# Bldgs	Total SF (1000's)	% of Tot Sq Ft	% of Bldgs	# Bldgs	Total SF (1000's)	% of Tot Sq Ft	% of Bldgs	# Bldgs	Total SF (1000's)	% of Tot Sq Ft		
Office	44,064	2	127	4,756	10.8	1	63	4,756	10.8	1	63	12,049	27.3	190000	
Restaurants	3,905	0	-	0	0.0	0	-	0	0.0	0	-	0	0.0	0	
Retail	24,054	1	64	2,403	10.0	0.6	38	2,883	12.0	0.6	38	4,998	20.8	130000	
Grocery	6,592	3	48	1,786	27.1	0.3	5	357	5.4	0.2	3	635	9.6	200000	
Schools	9,933	47	149	5,579	56.2	5	16	1,187	12.0	10	32	4,748	47.8	150000	
Colleges	4,661	5	2	86	1.9	0	-	0	0.0	20	9	3,685	79.1	400000	
Hospitals	6,535	9	14	526	8.1	16	25	1,871	28.6	10	16	3,587	54.9	230000	
Lodging	7,972	9	29	1,091	13.7	6	19	1,454	18.2	6	19	2,908	36.5	150000	
Refr Warehouse	1,413	16	8	307	21.7	4	2	154	10.9	10	5	614	43.5	120000	
Warehouse	25,137	10	269	10,078	40.1	4	107	8,062	32.1	1	27	3,225	12.8	120000	
Miscellaneous	25,103	2	142	5,323	21.2	1	71	5,323	21.2	0	-	0	0.0	0	
Total	159,369														

Data Source:

[1] PG&E Commercial Building Survey Report 1999. The number of customers in Table B-3 and the

% of premises in Table B-5 were used to develop the % of total square footage in this table.

[2] From the file received on 10/10/00 from Tav Cummins of CEC: flspsc_by_zone_1.xls, with the title: "Used for forecast in: California Energy Demand, 2000-2010, Publication # 200-00-002. July 14, 2000". The source table had the values broken out by climate zone and by utility. Just the totals are shown in the above table. Also, the large and small office were summed into the Total office column. The values shown in the above table are not used elsewhere in this table. Only the PG&E source numbers are used.

[3] See Note [1] on Table B-4 for special note and list of average areas used for the sectors in this category.

Column Formula Key:

B 1000's of SF for All of Calif: CEC projection for 2003 from Table B-3.

C 1000's of SF for PG&E by PG&E for 2000 from Table B-4. Used in this table for reference of the magnitude of PG&E's bldgs to all of Calif.

E % of Buildings: This was developed from earlier spreadsheet for PG&E territory (Table B-4) and fixed here for all of Calif.

F # of Buildings: Calculated from: $[G \times 1000 / E]$

G Total SF in thousands: This was calculated from the % of Tot SF and the Total SF. $[H \times B/100]$

H % of Total Sq Ft.: This was developed from earlier spreadsheet for PG&E territory (Table B-4) and fixed here and used to calculate Total SF in this size range for all of California.

I The average sf above 25,000 sf is calculated from Table B-4, but is not considered a very reliable number.

Totals for > 25,000 sf			
Sector	Tot SF (1000's)	# Bldgs	Avg sf
Office	21,561	254	85,000
Restaurants	0	-	-
Retail	10,284	141	72,955
Grocery	2,778	56	50,000
Schools	11,515	196	58,669
Colleges	3,772	12	327,500
Hospitals	5,984	55	109,643
Lodging	5,453	68	80,357
Ref Warehs	1,075	15	70,000
Warehouse	21,364	403	53,000
Misc	10,647	213	50,000
Total	94,432	1,412	66,888

Table B-7a and 7b. California Energy Rates/Cost Forecast and California Energy Use Indices and Energy Cost

Year	\$cents/KWH, blended rate--Elec						\$/MMBTU--Gas				
	PGE	SMUD	SCF	SDGE	LADWP	BGP	PGE	SCG	SDGE		
2000	9.912	8.250	9.290	9.276	9.074	12.572	7.694	6.629	7.796		
2001	9.637	8.021	9.033	9.019	8.823	12.223	7.370	6.770	7.808		
2002	7.489	5.930	7.240	7.724	6.213	7.512	6.655	5.938	6.861		
2003	7.029	6.267	6.866	7.605	6.544	7.838	5.439	4.803	5.656		
2004	7.270	6.638	7.064	7.942	6.909	8.195	4.877	4.077	4.700		
2005	7.552	7.043	7.266	8.268	7.311	8.588	4.822	4.146	4.762		
2006	7.875	7.490	7.566	8.672	7.757	9.029	4.850	4.133	4.697		
2007	7.829	7.501	7.485	8.602	7.766	9.036	4.911	4.214	4.758		
2008	7.482	7.536	7.420	8.566	7.801	9.069	4.895	4.232	4.827		
2009	7.458	7.548	7.370	8.502	7.814	9.082	Calif	4.915	4.263	4.892	
2010	7.468	7.588	7.394	8.508	7.852	9.122	Avg:	4.953	4.283	4.810	
Average	7.709	7.156	7.470	8.341	7.479	8.969	7.854	5.369	4.686	5.377	5.144

Source: These numbers were obtained from Lynn Marshall, Energy Specialist of the CEC. This retail price forecast has rates by planning area and commercial sector. Electric rates are based on commercial rates. Gas rates are based on core commercial rates. The filenames of the data received 10-25-00 are: gaspricecomp.xls and elec price and comp ced2000.xls. Ms. Marshall reported that the rates were a blended value that included typical demand charges.

Table B-7b. California Energy Use Indices and Energy Cost

Sector	A		B		C		D		E		F		G	
	Elec Use (Site)		Gas Use		Total Cost		Overall EUI		Unit Cost					
	kWh/sf/yr	\$/sf/yr	kBtu/sf/yr	\$/sf/yr	kWh/sf/yr	\$/sf/yr	kBtu/sf/yr	\$/sf/yr	kWh/sf/yr	\$/sf/yr	kBtu/sf/yr	\$/sf/yr	kWh/sf/yr	\$/sf/yr
Office	12.84	\$ 1.01	23.8	\$ 0.12	\$ 1.13		68	\$ 0.017						
Restaurant	35.62	\$ 2.80	210.07	\$ 1.08	\$ 3.88		332	\$ 0.012						
Retail	13.84	\$ 1.09	44.53	\$ 0.23	\$ 1.32		92	\$ 0.014						
Grocery	46.96	\$ 3.69	48.94	\$ 0.25	\$ 3.94		209	\$ 0.019						
Schools	6.82	\$ 0.54	35.25	\$ 0.18	\$ 0.72		59	\$ 0.012						
Colleges	10.44	\$ 0.82	64.81	\$ 0.33	\$ 1.15		100	\$ 0.011						
Hospitals	21.2	\$ 1.67	136.97	\$ 0.70	\$ 2.37		209	\$ 0.011						
Lodging	10.87	\$ 0.85	45	\$ 0.23	\$ 1.09		82	\$ 0.013						
Warehouse	22.36	\$ 1.76	16.77	\$ 0.09	\$ 1.84		93	\$ 0.020						
Warehouse	6.04	\$ 0.47	10.88	\$ 0.06	\$ 0.53		31	\$ 0.017						
Miscellaneous	12	\$ 0.94	49	\$ 0.25	\$ 1.19		90	\$ 0.013						

Column Formula and Source Key

- A Total of all electrical end uses per conditioned sf for PG&E, but assumed for entire state. Source: PG&E Commercial Building Survey Report 1999. The number of customers in Table 21.
- B From the average rate for all of Calif from Table B-7a above.
- C Use in PG&E territory and used for all of Calif in this table. Source: PG&E Commercial Building Survey Report 1999. The number of customers in Table 22.
- D From the average rate for all of Calif from Table B-7a above.
- E Col B + D
- F = elec kWh/sf/yr x 3413 Btu/kWh / 1000 Btu/kBtu + gas kBtu/sf/yr
- G Col E / F

Table B-8a. Commissioning Costs – Existing Buildings

(All of Calif.)	A	B	C	D	E	F	G	For Reference Only		
		Cx Consultant Labor (\$/sf)	Bldg Staff Labor Costs (\$/sf)	Cost of Fixes-- Materials and Labor (\$/sf)	Total Cx Cost (\$/sf)	Total Cx Cost FYI (\$)	Cx Provider Labor	Days @ \$90/hr	Bldg Staff C	Fix Cost
Office	85,000	0.26	0.04	0.04	0.34	\$ 28,900	\$ 22,100	31	\$ 3,400	\$ 3,400
Restaurant	-	0.26	0.04	0.02	0.32	\$ -	\$ -	0	\$ -	\$ -
Retail	72,955	0.26	0.04	0.02	0.32	\$ 23,345	\$ 18,968	26	\$ 2,918	\$ 1,459
Grocery	50,000	0.26	0.04	0.03	0.33	\$ 16,500	\$ 13,000	18	\$ 2,000	\$ 1,500
Schools	58,669	0.26	0.04	0.04	0.34	\$ 19,948	\$ 15,254	21	\$ 2,347	\$ 2,347
Colleges	327,500	0.26	0.04	0.03	0.33	\$ 108,075	\$ 85,150	118	\$ 13,100	\$ 9,825
Hospitals	109,643	0.33	0.07	0.07	0.47	\$ 51,532	\$ 36,182	50	\$ 7,675	\$ 7,675
Lodging	80,357	0.26	0.04	0.04	0.34	\$ 27,321	\$ 20,893	29	\$ 3,214	\$ 3,214

Column Formula and Note Key

* **NOTE:** Costs are based on a building of the Average sf Building size. Buildings smaller may cost considerably more per sf and buildings larger may cost considerably less per sf.

A From Table B-5.

B Commissioning Provider Labor: Includes focused effort on major energy using systems & limited effort at the zone level: review of building documents, equipment inspection, staff interviews, examination of controls (settings, schedules & system sequences) focused manual testing, trend log and/or datalogging and analysis, findings report including costs and savings estimates of recommendations (not extensive modeling), some assistance during fixes; selected retesting after fixes. No travel is included.

C Building staff time to assist the commissioning provider in getting documentation, interviews, inspections, limited testing, contracting for and coordinating fix execution.

D Materials and subcontractor costs for fixes (parts, mechanical contractor, controls programming, etc.). No major material expenditures included, e.g., adding a VFD is not included, but adding a sensor or two or a time clock would be.

E Total cost is the sum of Cx consultant, bldg staff and cost of fixes.

Cost Assumptions: (apply to both new and existing construction)

Labor annual salary (loaded) **\$ 80,000** CASalary (of Cx provider and owner staff)

Table B-8b. Commissioning Costs – New Construction

All of California	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
Sector	Avg sf > 25k	Cx Consultant Labor Costs		Designers & Contractors Costs		Owner Staff Costs		Total Cost--All Parties			Total Cost (\$)	Cx Provider Labor		Designer & Contractor Costs	
		Design (\$/sf)	Const. (\$/sf)	Design (\$/sf)	Const. (\$/sf)	Design (\$/sf)	Const. (\$/sf)	Design (\$/sf)	Const. (\$/sf)	Total (\$/sf)		Design	Const	Design	Const
Office	85,000	0.15	0.60	0.08	0.15	0.053	0.04	0.28	0.79	1.07	\$ 90,525	\$ 12,750	\$ 51,000	\$ 6,375	\$ 12,750
Restaurant	-	0.15	1.10	0.08	0.28	0.053	0.07	0.28	1.44	1.72	\$ -	\$ -	\$ -	\$ -	\$ -
Retail	72,955	0.15	0.60	0.08	0.15	0.053	0.04	0.28	0.79	1.07	\$ 77,697	\$ 10,943	\$ 43,773	\$ 5,472	\$ 10,943
Grocery	50,000	0.15	1.00	0.08	0.25	0.053	0.06	0.28	1.31	1.59	\$ 79,500	\$ 7,500	\$ 50,000	\$ 3,750	\$ 12,500
Schools	58,669	0.15	0.70	0.08	0.18	0.053	0.04	0.28	0.92	1.20	\$ 70,183	\$ 8,800	\$ 41,069	\$ 4,400	\$ 10,267
Colleges	327,500	0.15	0.45	0.08	0.11	0.053	0.03	0.28	0.59	0.87	\$ 284,311	\$ 49,125	\$ 147,375	\$ 24,563	\$ 36,844
Hospitals	109,643	0.20	0.75	0.10	0.19	0.070	0.05	0.37	0.98	1.35	\$ 148,498	\$ 21,929	\$ 82,232	\$ 10,964	\$ 20,558
Lodging	80,357	0.15	0.55	0.08	0.14	0.053	0.03	0.28	0.72	1.00	\$ 80,307	\$ 12,054	\$ 44,196	\$ 6,027	\$ 11,049

Table B-8b. Column Formula and Note Key

* Costs are based on a building of the Average sf Building size.

A From Table B-5.

B Design Phase Cx includes assisting in developing owner objectives, design reviews at schematic, design development and construction documents, developing a commissioning plan and developing cx specifications.

C Includes Cx cost of HVAC, controls, lighting controls and emergency power: submittal review, construction observation, construction checklist development, functional test writing and execution, verifying training and O&M manuals, seasonal testing and near-warranty end review.

D Includes designers costs for developing enhanced design narratives (assuming some narratives are already done in normal practice) and responding to commissioning provider design review comments and incorporating commissioning specifications into the project specifications.

E Includes designer's costs for commissioning meetings and reviewing commissioning plan. Includes contractor's costs for doing tasks they wouldn't do without commissioning, such as commissioning meetings, documenting installation and start-up and performing functional tests.

F Includes special commissioning meetings and distilling owner objectives and requirements from an existing programming report.

G Includes commissioning meetings.

K Total cost for all parties for the average building size shown in Column A.

L-Q Total cost for given party for the average building size shown in Column A.

MISC INPUT

Labor annual salary (loaded) **\$ 80,000** Salary
Cx provider utilization factor **0.80** Utilization

(Applies to commissioning provider, designers and owner staff.)
(Fraction that Cx provider is actually on commissioning projects, still assuming that is the only business they do. This factor is applied to the required FTE required.)

**Table B-8c. Workup of Cx Agent Design Phase Cost
85,000 sf Office For Tuning Inputs Above**

CA Task	hrs	\$ @ \$90/hr
Design obj.	16	\$ 1,440
Review 1	16	\$ 1,440
Review 2	20	\$ 1,800
Review 3	32	\$ 2,880
Specs	40	\$ 3,600
Total	124	\$ 11,160

**Table B-8d. Comparison of Above Cx Costs
% of Total Construction Cost Cx Cost Met**

Total Cx Cost Design and Construction--All Parties
(This table was created for reference in checking the
Assume total const cost in \$/sf = 120

Sector	Cx Cost as Fraction of Total Const (using \$/sf from above)	
	A Cx Agent Const Only	B All Parties & All Phases
Office	0.005	0.009
Restaurant	0.009	0.014
Retail	0.005	0.009
Grocery	0.008	0.013
Schools	0.006	0.010
Colleges	0.004	0.007
Hospitals	0.006	0.011
Lodging	0.005	0.008

Conclusion:

The Col A values correlate well with the typical 0.005 to 0.01 of total const cost for just the cx agent for construction only. So by the time design phase and other parties are added in, the Col B values of 0.006-0.012 are reasonable.

Appendix C: Survey Instruments

Appendix C provides the text of the telephone interview surveys that were conducted with commissioning providers and building owners.

Provider Survey Instrument

California Commissioning Market Characterization Survey- Providers

Surveyee's Name _____

Survey # _____

Company _____

Phone _____

Date/Time _____ **Interviewer** _____

Hello, this is _Say your name here_ from Portland Energy Conservation, Incorporated (PECI). We are conducting a confidential research study for Pacific Gas and Electric's (PG&E) publicly regulated utility group. We are seeking expert opinions in an effort to better understand what the California market is for quality assurance strategies such as building commissioning. We were given your name by ____ (Use the name off the spreadsheet list). We understand that you may have been involved in commissioning projects and may have an interest in seeing that market expand in California.

Could you take a few minutes to answer some questions about your firm and give us some of your personal opinions about building commissioning or if this isn't a good time could I schedule a better time for us to talk?

> [If No] Could you refer me to someone else who's opinions on commissioning may be valuable?

Use the following information as needed to answer the respondents questions.

Regarding length of survey: Because there are some open ended questions the survey can take anywhere from 20 to 40 minutes depending on the length of or discussions.

Regarding confidentiality: We will be supplying a list of names of respondents to PG&E but your answers to this survey will remain confidential.

Regarding PG &E: Let me clarify that we are calling on behalf of PG&E regulated, publicly funded, conservation group and not the unregulated energy service company

Regarding questions or concerns: refer them to Rafael Friedmann our project manager at PG&E. His phone # is (415) 972-5799.)

[If Yes] Great! We are guessing the survey will take between 25-35 minutes depending on the length of your responses. Is now a good time or would some other time be more convenient?

If NO, can we reschedule this at a more convenient time.

Reschedule date: _____ Time: _____

Thank you and I look forward to our call on xday at x o'clock.)

Respondent's Information:

Name of Contact Person: _____
Title: _____
Company Name: _____
Address: _____
City: _____
State: _____ Zip/Postal Code _____
Telephone: _____ Fax: _____ E-Mail: _____

Services offered, methods used, and baseline number of projects by type over last 2-3 years**1. How would you classify the primary business conducted by your firm? Check all that apply**

- ? Engineering
- ? Architecture
- ? A&E (both)
- ? Controls Contractor
- ? Mechanical Contractor
- ? TAB Contractor
- ? Design Build Contractor
- ? General Contractor
- ? Building Commissioning Contractor
- ? Operation & Maintenance Service Contractor
- ? Energy Service Company
- ? Construction Manager
- ? Other _____ (Please specify)

2. How many people does your firm employ?**3. Are you familiar with the term commissioning?**

- ? Yes
- ? No

4. **Is commissioning for new construction projects a service that you provide?**
 ? Yes
 ? No
5. **Is commissioning for existing buildings, which is sometimes called retrocommissioning, a service that you provide?**
 ? Yes
 ? No
6. **How do you define building commissioning as it applies to new construction projects(After they have explained their definition, read the following definition below and then go to question 7.)**

For the purposes of our survey, I'm going to read a common definition of building commissioning: Commissioning is a quality assurance strategy. It is a process that extends through all phases of a new construction or renovation project from concept to occupancy and operation. According to ASHRAE Guideline 1-1996, commissioning is *the process of ensuring that systems are designed, installed, functionally tested, and capable of being operated and maintained to perform in conformity with the design intent.* For the balance of the questions on commissioning, this is the definition we would like you to keep in mind when we use the term commissioning.

7. **How do you define commissioning as it applies to existing buildings? (Let the respondent answer, then explain our definition as follows and move to question 8.)**

For the purpose of this survey, I'm going to read a definition of retrocommissioning:

Retrocommissioning, also known as existing building commissioning, is a post-warranty event that applies a rigorous, systematic assessment and implementation process for improving a building's performance. It sometimes includes bringing the building systems back to their original intended design.

For the balance of the questions on retrocommissioning, this is the definition we would like you to keep in mind when we use the term retrocommissioning or existing building commissioning.

8. **If the respondent doesn't provide any commissioning or retrocommissioning services, ask why? And then skip to question 39 "JUST ASK * questions only ".**

9. Please indicate the average number of commissioning projects (by type) performed yearly by your firm over the last 2-3 years?

Type	# of Projects	# of Sq. ft.
New building construction-all building systems		
New construction-specific systems commissioning		
Renovation or equipment change out		
Retrocommissioning of existing building equipment		

10. Who contracts with you for your commissioning services? (Check all that apply)

- ? Building owner, directly
- ? The architect
- ? The general contractor
- ? The mechanical/electrical engineer
- ? The construction manager
- ? Utility
- ? Don't know
- ? Other: (Please specify)

11. How many employees in your firm currently perform commissioning services?

12. What percentage of your overall business is made up of commissioning services?

_____ %

13. How do you classify building commissioning in the mix of business services and products that you provide to your customers?

- ? Integral component to core business, provided as part of basic service
- ? Integral component to core business, provided as a differentiated service
- ? Separate component from core business, provided upon request

14. How long has your firm offered formal commissioning services?

- 15. For what sectors have you provided commissioning services?**
- ? High-rise Offices (3+ Stories)
 - ? Low-rise Offices (<3 Stories)
 - ? Hospitals
 - ? Laboratories/Cleanrooms/Research facilities
 - ? Universities
 - ? K-12 schools
 - ? Government facilities
 - ? Supermarkets/Cold Storage
 - ? Others: (Please specify)
- 16. At what stage of the construction process do you typically begin providing commissioning services? (check one)**
- ? Programming phase (pre-design)
 - ? Design phase
 - ? Construction / Installation phase
 - ? Warranty phase (occupancy phase)
- 17. What has been the earliest phase that you have begun a commissioning process?**
- ? Programming phase (pre-design)
 - ? Design phase
 - ? Construction / Installation phase
 - ? Warranty phase (occupancy phase)
- 18. How does your firm handle bidding/negotiating for commissioning services?**
- ? As a separate line item
 - ? As part of the standard service fee
 - ? Separate contract
 - ? Other:_____
- 19. What is your typical method for developing cost estimates for the commissioning services?**
- ? \$ per square foot
 - ? % of construction costs
 - ? % of mechanical costs
 - ? % of electrical costs
 - ? % of _____ costs
 - ? Contingency fee
 - ? Hourly breakdown cost estimate by task or piece of equipment
 - ? Other (please explain)
- 20. I will list a number of commissioning activities. Please indicate which ones I am routinely part of your firm's commissioning process for new construction projects:**
- | | | | |
|--|---|---|----|
| Documenting design decisions/criteria during programming | Y | N | DK |
| Commissioning-focused design review | Y | N | DK |
| Developing full design intent documentation | Y | N | DK |
| Verifying code compliance during design | Y | N | DK |

Developing system performance standards	Y	N	DK
Developing a comprehensive commissioning plan	Y	N	DK
Developing functional test protocols	Y	N	DK
Conducting/ or overseeing equipment functional tests	Y	N	DK
Verifying operator training	Y	N	DK
Performing operator training	Y	N	DK
Documenting sequence of operation	Y	N	DK
Approving O&M manuals	Y	N	DK
Developing a preventive maintenance program	Y	N	DK
Other activities not mentioned? List::			

21. When you are involved in commissioning a project, which types of documentation do you routinely develop?

- ? Contract language
- ? Bid specifications containing commissioning requirements & procedures
- ? Design intent documentation
- ? Prefunctional or verification checklists
- ? Functional tests
- ? Commissioning final report
- ? Systems manual or enhanced operation and maintenance manuals
- ? Track or document savings estimate, (cost, energy?)

22. Are there tasks that you routinely do as part of the commissioning process that your are not asked to do by your client?

23. What resources does your firm use in the commissioning process (check all that apply).

- ? Performance assessment tools and analysis software
- ? Commissioning guidelines
- ? Test libraries
- ? Portable data loggers
- ? Long-term monitoring
- ? Sample specifications
- ? Handheld measuring devices (thermometers, ammeters, flow hoods, light meters, etc.)
- ? Your own tools-(Please specify)
- ? Energy management system
- ? Do you use any other resources not already mentioned

24. Of the items checked above could you please tell us what specific items or tools you are using?

25. Which of these tools have you found most useful and why?

26. Have you used any of the following documents to assist you in developing your commissioning services? (check all that apply)

- ? ASHRAE Guideline 1-1989: Commissioning of HVAC Systems
- ? ASHRAE Guideline 1-1996: The HVAC Commissioning Process
- ? Building Commissioning Guidelines - Bonneville
- ? NEBB, "Procedural Standards for Building System Commissioning"
- ? Commissioning of Heating, Ventilating, and Air-Conditioning systems Guide Specification – Air Force/Army/Navy
- ? Montgomery County Commissioning Guideline
- ? U.S. DOE Model Commissioning Guide Spec.
- ? NIST HVAC Functional Inspection and Testing Guide
- ? Guide for Commissioning Existing Buildings – Oak Ridge National Laboratory
- ? Others? List:

Attitudes, goals, assessment of benefits/costs, satisfaction with commissioning

27. **In your opinion, what percent of new construction projects in California include commissioning? _____ % or _____ DK**
28. **In your opinion, what percent of existing buildings in California have gone through retrocommissioning? _____ % or _____ DK**
29. **In your opinion, do you think the market for commissioning services is:**
 ? Increasing significantly
 ? Increasing slightly
 ? Decreasing (skip to 31)
 ? Stable (skip to 32)
 ? Don't know (skip to 32)
30. **If Cx increasing, rank the following reasons for this increase in order of importance (1 low, 2 medium, 3 high):**
 1. 2. 3. Growth in total market for building construction and renovation
 1. 2. 3. Increased owner awareness and requests
 1. 2. 3. Changes in the electric utility industry
 1. 2. 3. Concern for professional liability
 Are there any other reasons you consider of high importance? (please describe) (skip to 32)
31. **If decreasing, why do you think this is occurring?**
32. **In your opinion, what do owner's perceive as the greatest benefit(s) of commissioning? (Do not Prompt)**
 ? Reduction in construction costs/less call back
 ? Energy savings
 ? Operational efficiency
 ? Building quality and comfort
 ? Longevity and reliability of equipment
 ? Indoor air quality
 ? Smoother turnover
 ? Other: (please describe)
33. **Are you satisfied with the current state of the commissioning market place? Why or why not?**

34. I'm going to read a list of methods for improving the quality of commissioning services. On a scale of 1 to 5, 1 being not at all effective and 5 being most effective, please rate the following strategies for increasing the quality of commissioning services:

Method	1 Not at all	2 Somewhat	3 Effective	4 Very effective	5 Most effective
Certification requirements for Cx Authorities					
Commissioning as a requirement in the four year college engineering curriculum					
Professional continuing education requirements					
A professional association just for Cx providers					
Standardization of commissioning requirements					
Standardization of system testing protocols					
Other:					

35. Do you think that commissioning services are cost effective? If so, how do you justify this statement?

? Yes
? No

36. How can the cost effectiveness be improved? (ASK THIS NO MATTER HOW THEY ANSWERED THE ABOVE)

Drivers for participation and perceived market barriers

37. Why did you first begin to offer commissioning services?

? Owner request
? Electric utility recommendation/requirement
? Business need / opportunity
? Project quality assurance
Other:

38. Can you tell me what you think the benefits of commissioning are? (Do not prompt)

? Fewer contractor call-backs

- ? Fewer warranty claims
 - ? Less litigation involving occupants, designers or contractors
 - ? Fewer building operator complaints.
 - ? Fewer occupant complaints
 - ? Takes less time to get system up and running optimally
 - ? Fewer post-acceptance operational deficiencies
 - ? More complete/higher quality operations and maintenance manuals
 - ? Greater energy efficiency
 - ? Increased equipment lifetime
 - ? Reduced operations and maintenance expenses
 - ? Increase productivity for building occupants
- Other: _____

***39. What are (or have been) the most significant barriers to your firm incorporating commissioning into your standard business offerings?**

***40 Do you feel any of the following are also barriers?**

- ? Your current fees don't cover the cost to include commissioning
- ? Clients do not request commissioning services
- ? Members of your firm are conflicted about the value of commissioning
- ? Your firm needs more information about the benefits of commissioning
- ? Your firm needs more training/expertise in commissioning practices
- ? Your firm lacks the tools/documentation to implement a viable commissioning service.

Other: _____

41. What types of tools (process management/diagnostics/analysis) could you use to enable you to provide more complete and efficient commissioning services?

***42. From a building owners perspective, what kinds of barriers do you think hinder their requesting commissioning service for new construction projects? (Do not prompt)**

- ? Lack of understanding of what commissioning is.
- ? The benefits and the costs are not well understood.
- ? Not knowing who to hire to perform commissioning services.
- ? A belief that commissioning is part of standard design/construction practices (they already get this service)
- ? Perceived added cost of commissioning
- ? The lines of responsibility in the design and construction team get confused if an independent agent performs the tests
- ? Disruption of construction schedule
- ? Lack of certification process for the commissioning providers
- ? Can't obtain funding for commissioning
- Other. _____

***43. From a building owners perspective, what kinds of barriers do you think hinder owners from requesting commissioning services for their existing buildings? (Do Not Prompt)**

- ? Lack of understanding what retrocommissioning is.
- ? The benefits and the costs are not well understood.
- ? Not knowing who to hire to perform retrocommissioning.
- ? A belief that their O&M staff or service contractors already do this.
- ? Lack of standardized retrocommissioning procedures
- Other. _____

***44. In your opinion, what needs to happen in the market place to increase demand for both commissioning and retrocommissioning services?**

- *45. I'm going to read a list of methods for increasing market demand for commissioning services. On a scale of 1 to 5, 1 being not at all effective and 5 being most effective, please rate the following strategies for increasing the demand for commissioning services:**

<i>Method</i>	1 Not at all	2 Somewhat	3 Effective	4 Very effectiv e	5 most effective
Tax credits					
Standardized commissioning procedures.					
Standardized commissioning specifications for construction documents					
Certification for commissioning firms					
Case studies that demonstrate benefits of commissioning					
Utility Financing Programs					
Code requirements for commissioning					
Non-financial awards programs such as free publicity in trade journals					
Marketing materials on Cx that you could hand to potential customers					
Education programs explaining commissioning procedures and benefits for building owners and their staff:					

- 46. We are also interested in what Cx service providers like yourself need to help you increase your skills and reputation as commissioning experts for both new building commissioning and retrocommissioning. Please rate on a scale of 1 to 5, 1 being not at all useful and 5 being most useful the following strategies:**

	1	2	3	4	5	DK
Informational workshops on state-of-the-art cx						
Articles in professional trade magazines showcasing cx projects						
Tools to increase delivery time such as software tools, automated tools, management tracking tools						
Advanced training workshops on design phase commissioning						
Training workshops on performance testing methods						
Comprehensive test libraries						
Informational workshops on how to sell cx services						

Implementation and technical problems encountered in commissioning, & corrective actions undertaken by whom.

- 47. What types of process/implementation problems frequently occur on your commissioning projects?**
- 48. What strategies are used to rectify these problems?**
- 49. What kinds of technical problem typically occur on your Cx projects?**

- 50. What strategies do you use to rectify these problems?**
- 51. We are also surveying building owners and managers to help determine what owners see as the value of commissioning and barriers to getting their buildings commissioned. Do you have any recommendations for names of owners that have been involved in a commissioning project that may wish to share their perspective with us?**
- 52. May we telephone you again at some point in the future as a follow up to this survey?**
? Yes
? No
- 53. Is there anything else you would like to tell us regarding how to improve building performance?**

Thank you for your participation

Owner Survey Instrument

Survey #: _____

Date Completed: _____

California Commissioning Market Characterization – Survey of Building Owners

Surveyor's Name _____

Company _____ **Phone** _____

Contact (Respondent) Name _____

Title: _____

Address (verify): _____

Phone: _____

Email: _____

Date/Time of contact:

Reschedule Date and Time:

Introduction

Hello, this is _Say your name here_ from Portland Energy Conservation, Incorporated (PECI.) We are conducting a confidential research study for Pacific Gas and Electric's (PG&E) publicly regulated utility group. We are seeking expert opinions in an effort to better understand what the California market is for quality assurance strategies such as building commissioning. We were given your name by ____ (Use the name off the spreadsheet list). We understand that you may have been involved in commissioning projects and may have an interest in giving us your opinion about the current cx market in California.

If Yes Great! Could you take a few minutes to answer some questions about your firm and give us some of your personal opinions about building commissioning or if this isn't a good time could I schedule a better time for us to talk?

If No, Could you refer me to someone else who's opinions on commissioning may be valuable?

Use the following information as needed to answer the respondents questions.

Regarding length of survey: Because there are some open ended questions the survey can take anywhere from 20 to 40 minutes depending on the length of our discussions.

Regarding confidentiality: We will be supplying a list of names of respondents to PG&E but your answers to this survey will remain confidential.

Regarding PG &E: Let me clarify that we are calling on behalf of PG&E's regulated, publicly funded, conservation group and not the unregulated energy service company

Regarding questions and concerns about who we are etc .:refer them to Rafael Friedmann, our project manager at PG&E. His phone # is (415) 972-5799.

Regarding availability of results: Because this is a confidential survey, PG&E will make available a report summarizing the results of the survey, once the research is complete. This will be available on PG&E's website.

General Information / Owners

1. What types of facility do you own and operate?(Check all that apply)

- ? Hospitals
- ? Long-term care or skilled nursing facilities
- ? High-rise commercial office buildings (3 stories or more).
- ? Low-rise commercial office buildings (1 to 2 stories).
- ? Laboratories / Cleanrooms/Research facilities
- ? Supermarket / Cold storage
- ? Retail stores
- ? Government facilities (type)
- ? Schools (K-12)
- ? University or college

Other: _____

2. We are interested in quality assurance practices for both new and existing buildings in California. Has your company built any new buildings or done any major renovations 100,000 sq. ft. or over in the past five years?

- ? Yes
- ? No – go to #5
- ? DK

3. If YES to question 2, ask: what is the approximate total square feet for all of these projects? _____

4. Can you tell us the percentage of new construction vs. renovation projects?

New_____% Renovations_____%

5. Is your company planning on building anything new within the next five years?

- ? Yes
- ? No - go to 8
- ? DK

6. If YES to question 6, ask: how many projects are you planning on building that are 100,000 sq. ft. or more? _____

7. What is the approximate total square feet for these planned new construction projects? _____

8. Is your company planning any major renovations in the next five years?

? Yes

? No - go to 11

? DK

9. If YES to question 8, ask: how many renovation projects 100,000 sq. ft. or more are planned?_____

10. What is the approximate total square feet for all of your planned renovations?_____

Commissioning Awareness

11. What type of quality assurance mechanisms or strategies do you integrate into your new construction projects to make sure you are getting buildings that perform as designed and meet your expectations (get what you are paying for)?

12. For your newest buildings, what significant building performance issues have you experienced?

13. Are you familiar with the term building commissioning?

NOTE: (If they mentioned commissioning in question 11, check yes here and move to question 13a.)

? Yes

? No

13a. If YES to question 13, ask: what does building commissioning mean to you as it applies to a new construction project? (After they have explained their definition, read the following definition below and then go to question 14.

Define what building commissioning means as follows

For the purposes of our survey, I'm going to read a common definition of building commissioning: Commissioning is a quality assurance strategy. It is a process that extends through all phases of a new construction or renovation project from concept to occupancy and operation. According to ASHRAE Guideline 1-1996, commissioning is *the process of ensuring that systems are designed, installed, functionally tested, and capable of being operated and maintained to perform in conformity with the design intent.*

For the balance of the questions on commissioning, this is the definition we would like you to keep in mind when we use the term commissioning.

13b. Also, If NO to question 13, ask are you interested in learning more about building commissioning from PG&E.

? Yes If appropriate, query on what aspects of cx they'd like more info. on?

? No why not?

13c If NO to 13b, ask: what would influence you to change your mind?

For those answering NO to question 13, SKIP to QUESTION 27 under Retrocommissioning Awareness

Commissioning Experience

The following questions have to do with your commissioning experience.

14. Have any of your buildings or systems ever gone through a commissioning process during construction, retrofit, or a major renovation?

? Yes

? No **If NO, SKIP to QUESTION 27** under Retrocommissioning Awareness

? DK **If DK, SKIP to QUESTION 27** under Retrocommissioning Awareness

15. How many of your projects have involved some type of commissioning?

- 16. For each of your three most recent projects, could you tell me (read each column heading separately and fill in information for each project using the table below)**

Type building?	Year each commissioned?	Approximate sq. feet?	Commissioning Cost?	New (N) Retrofit (RT) or Renovation {RN}?

- 17. Were you happy with the results from your commissioning project?**
 ? Yes
 ? No What made you unhappy about the results?
- 18. If YES to question 17 ask: what did you value most about the commissioning process? (If they mention any benefits listed in question 19 below, put an M for MOST in the adjacent check box.)**
- 19. The following is a list of benefits often realized through the commissioning process. Did you realize any of these benefits? (read and check (✓) only the issues that they didn't mention in question 18)**
- ? Reduced construction / warranty issues (less call backs and change orders)
 - ? Improved comfort control
 - ? Increased equipment reliability
 - ? Reduced O&M issues (less fine tuning during occupancy, less trouble calls)
 - ? Increased energy savings
 - ? Record of system operation and control sequences.
 - ? Improved O&M manuals and training of O&M staff.
 - ? Smoother turnover
 - ? Reduced IAQ issues
 - ? Other: _____

- 20. I will list a number of commissioning activities. Please indicate (by saying yes, no, or don't know) which of these commissioning activities were included in your commissioning process:**

Documenting design decisions/criteria during programming	Y	N	DK
Commissioning-focused design review	Y	N	DK
Developing full design intent documentation	Y	N	DK
Verifying code compliance during design	Y	N	DK
Developing system performance criteria	Y	N	DK
Developing a comprehensive commissioning plan	Y	N	DK
Developing functional test protocols	Y	N	DK
Conducting/ or overseeing equipment functional tests	Y	N	DK
Verifying operator training	Y	N	DK
Performing operator training	Y	N	DK
Documenting sequence of operation	Y	N	DK
Approving O&M manuals	Y	N	DK
Developing a preventive maintenance program	Y	N	DK
Other activities not mentioned? Please list:			

- 21. What type firm is generally hired to do commissioning on your projects? (Check all that apply. Only prompt if needed)**

- ? Architectural
- ? Test, Adjusting, and Balancing (TAB) contractor
- ? Mechanical/Electrical engineering firm
- ? Consulting engineering firm
- ? Commissioning consultant
- ? Don't Know
- ? Other: (Please specify)

- 22. For your projects that included commissioning, who contracts for (directly hires) the commissioning services? (Check all that apply. Only prompt if needed)**

- ? Building owner, directly
- ? Architect
- ? General contractor
- ? Mechanical/Electrical engineer
- ? Construction manager
- ? Utility
- ? Don't know
- ? Other: (Please specify)

- 23. I'm going to read a list of construction phases, please tell me for your projects which stages of the construction project include commissioning activities**

- ? Programming (pre-design phase)
- ? Design (bid) phase
- ? Construction phase
- ? Post construction / warranty phase

24 . Why do you begin commissioning at the _____ stage in the construction process? (Note to surveyor: referring to question 23, fill in the blank with the first construction stage where they mention that Cx activities occur.)

25. Do you plan to use commissioning as a quality assurance strategy in any of your future projects?

? Yes

? No Why not?

26. If YES, ask: could you tell me the type buildings that you are planning to commission and their approximate square footage?

Building type	Approx. sq.feet

Retrocommissioning Awareness / O&M Strategies / Needs

27. This next group of questions address quality assurance strategies for existing buildings. How many existing buildings do you own and operate in California?

28. Who primarily operates and maintains your California buildings? (Check all that apply, prompt if necessary)

? In house O&M staff If YES, ask how many are employed? _____

? Maintenance service contractors as part of a service contract agreement

? Maintenance service contractors that are called when needed

? Combination of in-house O&M staff and service contractors

29. Do you use any of the following strategies to ensure building performance in your existing buildings?

(Read directly through the list, check all boxes where the respondent answers **yes**, and write **“DK”** in all boxes where the respondent doesn’t know. After completing the list, go back to all questions where the respondent answered yes and complete the extended question)

? Monitoring and troubleshooting using handheld tools (multimeters, ammeters, flowhoods etc)

? Trend logging through the energy management control system

? Comparative analysis of the trend log data that is gathered by the energy management control system?

If YES ask: how is the analysis accomplished?

- ? Short-term monitoring of systems and temperatures using portable data acquisition equipment
 - ? Long term monitoring of systems using permanently installed metering equipment
If YES, ask: would you please describe this strategy?
 - ? Energy accounting software for tracking and analyzing utility bills
Scheduled preventive maintenance
If YES, ask: Is scheduling done through a:
 - ? Computerized Maintenance Management System (CMMS)
 - ? Manual maintenance log
 - ? Service contract
 - ? Periodic rigorous and systematic O&M assessments and tune ups
If YES, ask: who performs these types of tune-ups
 - ? Periodic training for O&M staff
If YES, ask: Please describe your training program?. (prompt: what might trigger training? How often does staff get trained?)
- 30. What other mechanisms or strategies, such as software or assessment tools (that haven't already been mentioned), do you use to ensure that your existing facilities perform optimally regarding comfort and efficiency?**
- 31. What types of software or assessment tools, that you don't already use would benefit you in troubleshooting and operating your buildings? You might wish to describe tools that may or may not exist in the marketplace.**
- 32 In what areas do you feel your building operators could use more training?**
- 33. Please rank from 1 to 3 the importance of each of the following concerns for proper operation and maintenance of your facilities, one being of least importance, 2 being important and three being the highest or most important.**

O&M Concerns	1 Least	2 Important	3 Most
Indoor air quality			
Fire, life safety issues			
Occupant / tenant			

comfort			
Preventative maintenance			
Reducing energy costs			
Equipment longevity and reliability			
Having a proper understanding of how the systems are intended to operate			
Operator training			
Ease of equipment repair and installation			

Are there any other concerns that you consider most important that haven't been mentioned?

34. Are you familiar with the term retrocommissioning or existing building commissioning?

? Yes
? No

34a. If YES, ask: as you understand it, what does retrocommissioning (existing building commissioning) entail? (Let the respondent answer, then explain our definition as follows and move to question 35.).

If NO to 34, define retrocommissioning as follows:

For the purpose of this survey, I'm going to read a definition of retrocommissioning:

Retrocommissioning, also known as existing building commissioning, is a post-warranty event that applies a rigorous, systematic assessment and implementation process for improving a building's performance. It sometimes includes bringing the building systems back to their original intended design.

For the balance of the questions on retrocommissioning, this is the definition we would like you to keep in mind when we use the term retrocommissioning or existing building commissioning.

34b. Also, if NO to 34 ask: would you be interested in learning more about retrocommissioning from PG&E.

? Yes
? No **why not?**

34c. If NO, ask: what would influence you to change your mind?

If NO to question 34 but the respondent is familiar with commissioning for new construction
SKIP TO QUESTION 43 (Market opinion).

(END THE SURVEY HERE if the respondent is unfamiliar with both commissioning and retrocommissioning. Thank them for their time.)

35. If YES to question 34, ask, given the definition that I just read, have any of your existing buildings ever gone through a retrocommissioning process?

- ? Yes If YES, fill in table below
? No **SKIP to QUESTION 43 (Market opinions)**
? DK **SKIP to QUESTION 43 (Market opinions)**

36. For your three most recent projects, could you tell me

The building types retrocommissioned?	Year retrocommissioned?	Approximate sq. ft?	Approximate cost to retrocommission?

37. Which budget did the funding for the retrocommissioning come from?

38. Were you happy with the results from the retrocommissioning project?

- ? Yes
? No **Would you explain more about that?**

39. If YES ask to question 38, ask: what do you value most about having your buildings go through the retrocommissioning process? (If they mention any benefits listed below in question 40, put an M in the check box for MOST)

40. The following is a list of benefits often realized through a retrocommissioning process. Did you realize any of these benefits? (Read and check (✓) only the issues that they didn't mention in question 39.)

- ? Improved comfort control
? Increased equipment reliability
? Reduced O&M issues (less comfort and trouble calls)
? Improved operating strategies
? Increased energy savings
? Improved training for O&M staff

- ? Improved understanding of system operation
- ? Improved O&M manuals
- ? Reduced IAQ issues
- ? **Other:** _____

41. Is your company planning to perform any rigorous O&M tune-ups or retrocommissioning type activities on any of your facilities within the next five years?

- ? Yes
- ? No **If NO, ask: why not?**
- ? DK

42. If YES, ask: could you tell me the type of buildings that you are planning to retrocommission and their square footage?

Building type	Approx. sq.feet

Commissioning / Retrocommissioning Market Opinions

The next group of questions addresses the barriers to increasing the market demand for commissioning and retrocommissioning services as well as strategies for overcoming the barriers.

- 43. On a scale of 1 to 3 please rate the each of the following barriers to making commissioning or retrocommissioning part of standard industry practice with 1 being the least significant, 2 being significant, and 3 being the highest or most significant barrier.**

Barriers to commissioning or retro-commissioning construction projects	1 Least Significant	2 Significant	3 Most significant
Lack of general awareness about what commissioning or retro commissioning is.			
Perceived high cost for commissioning or retrocommissioning			
Perceived additional time required to complete commissioning tasks, thus slowing the construction process.			
Perceived additional time required by O&M staffs to participate in the retrocommissioning process			
Lack of available commissioning providers to perform commissioning or retrocommissioning			
Lack of documented costs and benefits			
Lack of budget			
Lack of certification process for commissioning providers			
Lack of support by senior decision makers in your company			

What other barriers can you think of that we haven't mentioned?

44. I'm going to read a list of methods for increasing market demand for commissioning services. On a scale of 1 to 3, 1 being least effective, 2 being effective and 3 being highly or most effective, please rate the following strategies for increasing the demand for commissioning services.

Method	1 Least Effective	2 Effective	3 Most effective
Tax credits? (give examples)			
Example commissioning specifications for construction documents			
Certification for commissioning providers			
Low or no cost informational workshops on building commissioning and retrocommissioning			
Demonstration projects and case studies that demonstrate benefits of commissioning in new and existing buildings			
Funding of Commissioning Activities by Utility EE Programs			
Code requirements for commissioning of new buildings			
Increased availability of commissioning related information (on the web and in professional journals) targeted at building owners and managers			

Can you think of any other strategies that would greatly influence you to include commissioning in your new construction project?

Can you think of any other strategies that would greatly influence you to retrocommission your existing buildings?

45. Who in your organization needs to be convinced about the value of commissioning or retrocommissioning before you could implement these strategies for your buildings?

46. Is there anything else that you would like to add regarding strategies and tools that help improve building performance?

47. Could you recommend names of any other building owners or managers that could give us opinions or valuable input into this research?

Name:

Contact Info:

48. May we call you again to follow up on this survey? _____

Thank you for taking the time to complete this survey