Excerpted Information on Potential Commissioning Costs and Energy Savings from:

Final Report

California Commissioning Market Characterization Study

A Report Prepared for Pacific Gas and Electric Company

By

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The information contained in this study was developed for the internal use of Pacific Gas and Electric Company (PG&E). PG&E makes no warrant as to its level of certainty or accuracy.
Excerpted from the Executive Summary

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 estimated annual new 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.

Excerpted from the Body of the Report

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

<table>
<thead>
<tr>
<th>Sector</th>
<th>Energy Savings Fraction</th>
<th>Total Cost of Cx and Fixes ($/sf)</th>
<th>Total Floor Area (millions of sf)</th>
<th>Annual Penetration Rate</th>
<th>Area Commissioned (1000’s sf/yr)</th>
<th>Annual Energy Savings (Millions of kBtu)</th>
<th>Annual Energy Dollar Savings (Millions)</th>
<th>Payback From Energy Alone (yrs)</th>
<th>Needed Commissioning Consultant FTE</th>
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</thead>
<tbody>
<tr>
<td>Office</td>
<td>0.15</td>
<td>$ 0.34</td>
<td>722.00</td>
<td>0.020</td>
<td>14440.0</td>
<td>146.5</td>
<td>$ 2.45</td>
<td>2.0</td>
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<td>$ 0.32</td>
<td>0.00</td>
<td>0.020</td>
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<td>0.0</td>
<td>$ -</td>
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<tr>
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<tr>
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<td>$ 0.33</td>
<td>101.94</td>
<td>0.020</td>
<td>2038.8</td>
<td>51.2</td>
<td>$ 0.96</td>
<td>0.7</td>
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<tr>
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<td>$ 0.34</td>
<td>558.34</td>
<td>0.020</td>
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<td>268.70</td>
<td>0.020</td>
<td>5374.0</td>
<td>168.7</td>
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<td>1.3</td>
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</tr>
<tr>
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<td>0.020</td>
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<td>1.8</td>
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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

<table>
<thead>
<tr>
<th>Sector</th>
<th>Energy Savings Fraction</th>
<th>Total Cost of Cx In Design and Const ($/sf)</th>
<th>Total New Const. Floor Area (millions of sf)</th>
<th>Annual Penetration Rate</th>
<th>Area Commissioned (1000’s sf/yr)</th>
<th>Annual Energy Savings (Millions of kBu)</th>
<th>Annual Energy Dollar Savings (Millions)</th>
<th>Payback From Energy Alone (yrs)</th>
<th>Needed Commissioning Consultant FTE</th>
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<tr>
<td>Office</td>
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Column heading letters correspond to headings of the source Table B-2.